THE JOURNAL OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

OCTOBER 1958

Volume 52, Number 5 Whole Number 434

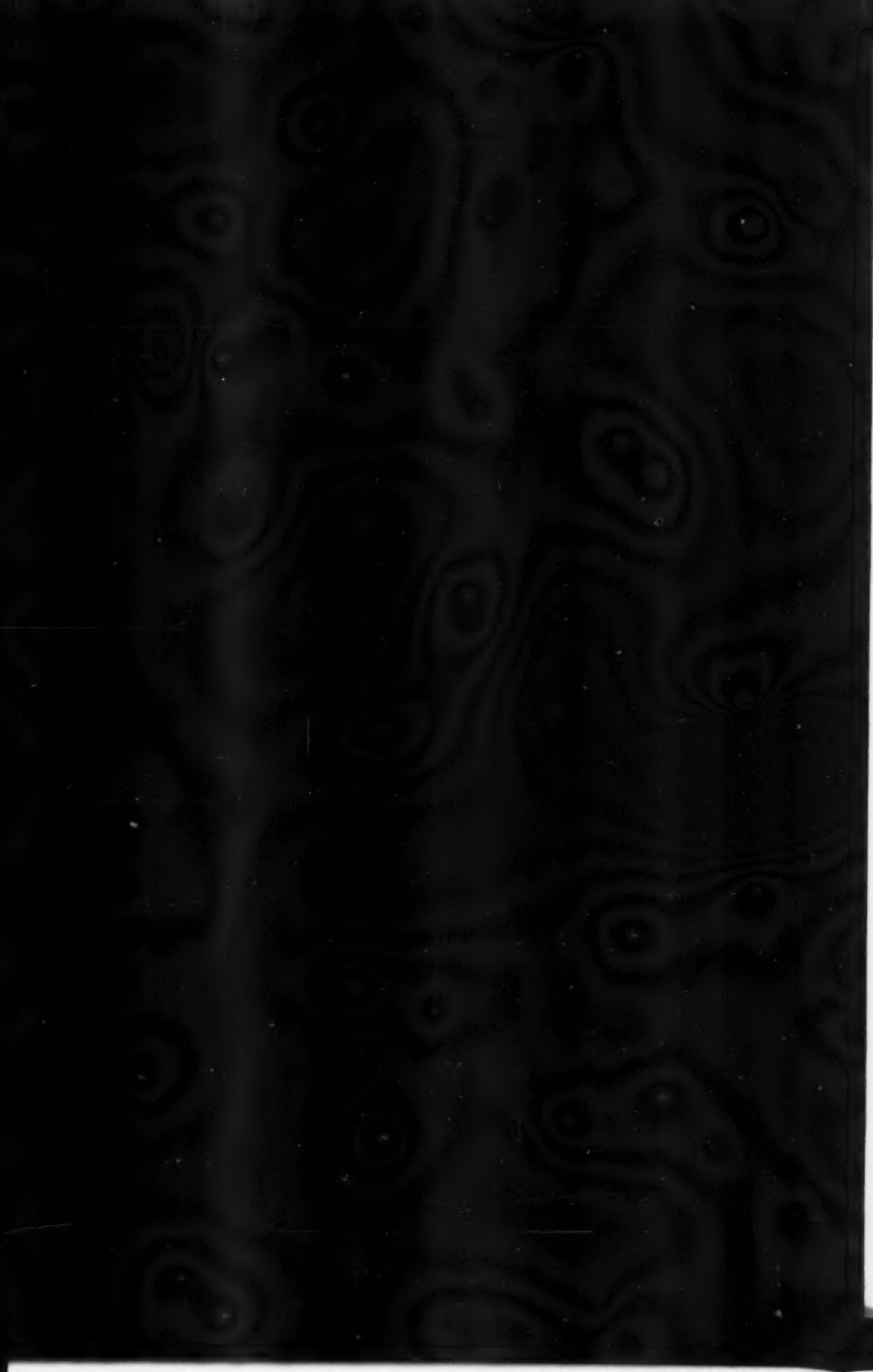
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

NATIONAL OFFICERS AND COUNCIL FOR 1958

Honorary President—The Honourable W. J. DUNLOP, D.PAED., Minister of Education for Ontario.
President—HELEN S. HOGG, PH.D., Toronto.
First Vice-President—ANDREW MCKELLAR, PH.D., Victoria.
Second Vice-President—PETER M. MILLMAN, PH.D., Ottawa.
National Secretary—J. E. KENNEDY, M.SC., 252 College Street, Toronto 2B.
National Treasurer—J. H. HORNING, M.A., 252 College Street, Toronto 2B.
Recorder—FREDERIC L. TROYER, Toronto.
Librarian—W. T. TUTTE, PH.D., Toronto.
Council—Elective Members: MIRIAM S. BURLAND, Ottawa; A. VIBERT DOUGLAS, Kingston; CARL REINHARDT, Toronto; Past Presidents: R. M. PETRIE, Victoria; JOHN F. HEARD, Toronto.

Halifax Centre: Rev. M. W. BURKE-GAFFNEY, S.J., L. CARRIGAN (Pres.).
Quebec Centre: PAUL H. NADEAU, J. ALFRED DUMONT (Pres.).
Montreal Centre: G. HARPER HALL, A. R. MACLENNAN (Pres.).
Centre Français de Montréal: J. R. GRIGNON, JEAN ASSELIN (Pres.).
Ottawa Centre: J. L. LOCKE, J. E. LILLEY (Pres.).
Toronto Centre: MRS. K. M. HEATON, G. A. COOPER (Pres.).
Hamilton Centre: H. B. FOX, REV. N. GREEN (Pres.).
London Centre: W. G. GRAHAM, W. WEHLAU (Pres.).
Windsor Centre: ————————, E. W. KEITH (Pres.).
Winnipeg Centre: R. J. LOCKHART, J. SCATLIFFE (Pres.).
Edmonton Centre: E. S. KEEPING, EARL MILTON (Pres.).
Calgary Centre: ————————, WALTER H. STILWELL (Pres.).
Vancouver Centre: G. M. SHRUM, R. J. CLARKE (Pres.).
Victoria Centre: R. S. EVANS, N. G. ROGERS (Pres.).

PRINTED IN CANADA
BY THE UNIVERSITY OF TORONTO PRESS



THE JOURNAL OF THE
ROYAL ASTRONOMICAL SOCIETY
OF CANADA

Vol. 52, No. 5 OCTOBER 1958 Whole No. 434

STANDARD TIME AND TIME ZONES IN CANADA

By C. C. Smith

Revised by M. M. Thomson
Dominion Observatory, Ottawa, Ontario

Introduction

Many questions on matters relating to standard time are referred to the Dominion Observatory. This publication is a compilation of the answers to those questions that are most frequently asked.

No map showing the positions of the time zones in Canada has previously been available. The explanation of why the times of watches have to be changed in travelling east or west will, it is hoped, prove sufficiently descriptive and definite. The chart of time zones of the world has for some time been in considerable demand.

The faster means of transportation and communication made possible in recent years by the aeroplane, the automobile, the radio, and wireless telegraphy, together with the greater interest thus developed in affairs in distant places, have made necessary a much more general knowledge of corresponding times and related questions.

To the officers of different legal departments and to others who have kindly furnished replies to questions, the writer wishes to express due appreciation. Acknowledgment is also made of the use of material from the national ephemerides. In the preparation of the material a very considerable part has been taken by Miss K. Nevins of the observatory staff.

Introduction to Revised Edition

Since the original publication of this pamphlet by the late Mr. Smith, many changes have occurred. Newfoundland has joined confederation to

become the tenth Canadian province; provincial legislation has in some instances been modified; methods of communication and transportation have brought all parts of the world closer together.

Improved methods of observing the time, together with the development of quartz crystal and atomic clocks, have resulted in a revaluation of the unit of time, the second. Hence some sentences in the original publication have been changed and new portions added.

Again thankful acknowledgment is made to the officers of different legal departments for assistance; to the officers of the national almanac offices for the use of information in the ephemerides; and to Mrs. B. Crawford and other members of the observatory staff for assistance in preparing the manuscript.

The Unit of Time—The Day

What time is, of course, nobody knows; one man's guess is as good as another's. Fortunately this lack of a satisfactory definition is for most purposes no great handicap; all that is necessary is to be able to measure time. How many days before this did that event happen—or how many days after? These are, for the most part the only questions concerning time that have to be answered, the former affording the time order for writing the history of the things that are past, the latter assisting in planning or predicting the things that are to come.

For the measurement of time there was supplied, when the earth was created, an almost perfect clock. The earth was sent into space spinning around on its axis and it has since continued to travel in an orbit, almost circular, about the sun. The time needed for one rotation of the earth on its axis, a day, is a practical unit of time. Since the easiest way to count the days is to note each time that the rotation brings the sun overhead, a solar day has always been used as the ordinary unit of time. Since the earth in its yearly journey around the sun moves in an orbit which is not quite circular, the days obtained by observing successive passages of the sun are of unequal length, and the day adopted as the practical measure of time is the average or mean solar day. It is evident that the rotations of the earth could be checked off by watching for the passing of any other mark in the sky, as for instance any particular star, and this is the favourite method used by time observers to obtain accurate time. By a simple calculation the time obtained by such observations is transformed into mean solar time.

The Second

The unit of time has been defined as 1/86,400 of a mean solar day. The increased precision of modern timekeepers has made it evident that the

rotation of the earth, and hence the length of the fundamental unit of time, the second, suffers small irregularities during the year. One source of irregularity is caused by polar wandering, and this is measured directly as a change in latitude. Another source is due to a slowing down of the earth in the spring of the year followed by a speeding up in the fall. The precision of modern timekeepers has been responsible for disclosing this irregularity. By international agreement, effective January 1956, corrections to compensate for these two sources of irregularity have been applied to astronomically observed time. The resulting corrected value of the observed second has since been available to assess the performance of observatory clocks and frequency standards. Furthermore the second has as of 1956 been defined as 1/31,556,925.974 of the tropical year for 1900 January 0 at 12 hours ephemeris time, and modern methods of observation make it a practical unit.

Local Time

Until a few hundred years ago the earth was almost universally regarded as a stationary object, and many attempts were made to explain the sun's daily journey across the sky. For example, there is the ancient myth that the wheels of Apollo's chariot came rolling out of the east in the morning, drove the shades of night westward across the sky, and in the evening descended into the western sea. It was only in the sixteenth century that men became convinced that the earth rotated on its axis. Now, with the help of a globe to represent the earth and a lighted lamp placed near the plane of the equator to represent the sun, every schoolboy learns of the rotation of the earth on its axis causing alternate day and night. Also by moving the globe around the lamp, care being taken to keep the axis pointing always in the same direction, the boy is taught the yearly journey of the earth around the sun. He sees that the sun is continually south of the equator in winter and north of it in summer, and he also sees the great circle which marks the dividing line between day and night, constantly changing its position relative to the equator and the poles. It is easily apparent that in Canada there is a much greater variation in the duration of daylight than in countries nearer the equator.

He learns that on account of the rotation of the earth on its axis a point on the equator travels from west to east at the rate of about 1,000 miles an hour, at 40° latitude at about 800 miles an hour, at 60° latitude at about 500 miles an hour, the rate of travel decreasing to zero at the poles. He can see the lighted half and the dark half of the earth, and the great circle, forming the dividing line between day and night, shifting;

towards the west as the earth is rotated. Choosing any one point on the globe he sees it move from the dark side across this dividing line into sunlight in the morning, advance through sunlight to be most nearly under the sun at noon, and cross the dividing line at evening into darkness. On the globe our schoolboy sees Canada stretching east and west nearly one-quarter of a complete circuit, so that when the eastern part is crossing the line from darkness into sunlight the western part is still far around in the night. Later on when Nova Scotia has advanced to noon it will be morning in Yukon Territory.

It is an old custom to have clocks set so that noon comes as nearly as possible at 12 o'clock. Obviously then the clocks in eastern Canada must be set several hours ahead of the clocks in western Canada, and similar differences of time occur on all the clocks as one goes from east to west around the earth. The result is that only those places on the same north and south line have the same time. One hundred years ago people got the time for their clocks from the church clock, or the town clock, or sun-dials, or perhaps from a primitive observatory. Each community had its own local time. Later the invention of telegraphy increased communication facilities between the different towns and countries, and the building of railways with their faster means of travel through the different communities made so many different local times exceedingly inconvenient and confusing. For instance, at one time a traveller, in going from Halifax to Toronto, had to change his watch at Saint John, Quebec, Montreal, Ottawa, and Toronto.

Standard Time

In England the very great inconvenience of running railway trains through town after town, separated by only a few miles but each with its own local time, was met by adopting the local time at Greenwich Observatory as the time to be used throughout the whole country. In the United States, since local time in the east was four hours ahead of local time in the west, the use of a single time all across the country would have brought 12 o'clock in some localities several hours before or after noon, and hence the railways divided the country into four regions, which they called Eastern, Central, Mountain, and Pacific, the time used in these zones being five, six, seven, and eight hours, respectively, slower than Greenwich time. The change from one time to another was made at divisional points on the several railways. This time, used by the railways, which went by the name of "railway time", was adopted by most towns in place of their own local time.

From 1878 Sir Sandford Fleming had been advocating the use, through-

out the world, of what are called standard time zones. At a world conference held at Washington in 1884, his suggestions were adopted and it was agreed to urge all countries of the world to use standard time zones. This scheme was a compromise between the intolerable confusion of a multitude of local times and the apparently impractical ideal of a single universal time with all clocks marking the same time irrespective of the various local times. Fleming proposed that the number of times in the world should be reduced to twenty-four. Each time zone would extend over one twenty-fourth of the circumference of the earth and would include all the territory between two meridians fifteen degrees apart, each zone being 1,038 miles wide at the equator and narrowing down to nothing at the poles. In each zone the time to be used was to be the local time at the central meridian of the zone. The first, or zero zone, was to be that having Greenwich as the central meridian and comprising that part of the earth between the meridians seven and one-half degrees east and west of Greenwich, respectively. The local time at the Greenwich meridian was to be, then, the standard time of the first zone. Westward from Greenwich the different standard time zones would use the local time at the meridians 15°, 30°, 45° . . . 180° west of Greenwich, and eastward the local time at the meridians 15°, 30°, 45° . . . 180° east of Greenwich. Some of these standard time zones have received generally accepted names, Mid-European and East European having times respectively one hour and two hours greater than Greenwich, while Atlantic, Eastern, Central, Mountain, Pacific, Yukon, and Alaska have times four, five, six, seven, eight, nine, and ten hours, respectively, less than that of Greenwich. The other zones are generally designated by their difference in time from Greenwich.

Almost all large countries of the world have adopted the use of standard times differing by some integral number of hours from the local time at the Greenwich meridian, but many smaller countries and localities use an adopted time differing by other than whole hours. The province of Newfoundland, which includes Labrador, uses time 3 hours 30 minutes less than Greenwich. Many other such examples are seen in the appended list of standard times. In this list the term "standard time" is used to include such adopted times, though these were not included in the twenty-four standard times as originally defined.

In Canada practical difficulties have prevented the eastern and western boundaries of the time zones from being placed exactly on the contemplated meridians. The railways already had arranged for change of time at divisional points. The provinces and territories enacted laws as to what time was to be used within the boundaries of their jurisdiction,

and consequently in many cases provincial and territorial boundaries became boundaries of time zones.

International Date Line

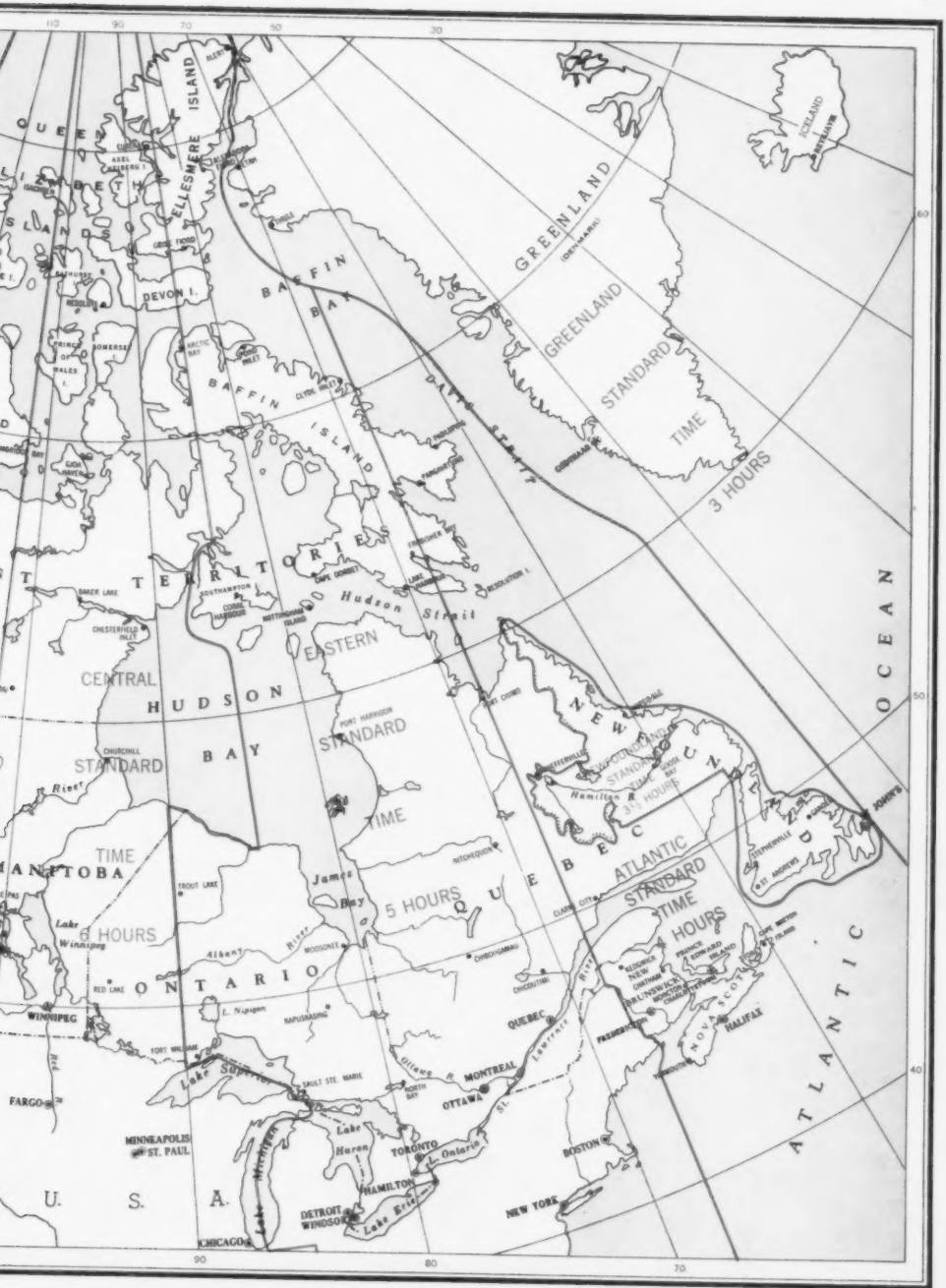
The use of time zones reduced the confusion and inconvenience formerly arising from the use of a multitude of local times and made it fairly easy to answer the very frequent question, "What is the time in one place corresponding to a given time in some other place?" There still remained some uncertainty as to the date at any instant at different points on the earth's surface.

The sailors who first circumnavigated the globe, sailing westward, are reported to have been surprised to find, on arriving again at the starting point, that the date in their log differed by one day from the date kept at their home port. They had "lost" a day. Those who sailed easterly around the globe "gained" a day. In neither case did they gain or lose any time, the days being longer going west and shorter going east. Imagine an aviator setting out from Greenwich at 2 p.m. and travelling westward at a speed of 658 miles per hour, the same as the speed of rotation of the earth's surface at that latitude. The sun would remain in the same direction overhead. The local clocks the aviator saw while passing over North America would all show 2 p.m., though his clock in the plane would show successively 6, 7, 8, 9, and 10 p.m. Continuing on around the world, the flier would find all local-time clocks showing 2 p.m., and would arrive back in London at 2 p.m. Although from his observations of local-time clocks he had appeared to fly around the earth in no time, he would, on his return, find it 2 p.m. of the day after his date of departure—as indeed the clock he carried would prove. Had he set his clock back to local time every time he saw a town clock, he would have "lost" a day as the sailors did.

To avoid complications of this kind, it was agreed to use the meridian of 180° on the other side of the earth from Greenwich as a date line, a place to add the lost day when going west and to subtract the gained day when going east. In order that the date line may not pass through settled lands it is deflected westward around Alaska and eastward to include Chatham Islands and Tonga Islands.

The date is assumed to start when it is midnight at this meridian, then as this midnight point sweeps westward around the earth all that part west of the 180th meridian has the new date, one day later than that east of this "date line" until the midnight point reaches the date line again. Then, for an instant all the earth has the same date, but the next

Dominion Observatory, Department of Mines and Technical Surveys



Produced by the Surveys and Mapping Branch, Ottawa, Canada.

instant the midnight point commences to sweep a new date westward from the date line.

Standard Time Zones of Canada

Canada extends east and west almost 90 degrees. Thus it happens that when the shores of Newfoundland are heralding the dawn of a new day, the clocks in Whitehorse, Yukon, are registering midnight. There are in fact seven different time zones across Canada. When it is five-thirty a.m. in St. John's, Newfoundland, it is five a.m. in Halifax, four a.m. in Ottawa, three a.m. in Winnipeg, two a.m. in Calgary, one a.m. in Victoria, and midnight in Whitehorse. During the interval that any locality is observing daylight saving time, it is simply adopting the standard time of the zone to the east and starting the day an hour earlier.

The legal boundaries of the time zones are shown on the accompanying map. With the exceptions of Quebec, Ontario, and the Northwest Territories, each province has adopted a single standard time.

NEWFOUNDLAND Standard Time, which is the local time at the meridian 52½° west of Greenwich (running near St. John's, Newfoundland), is three and one half hours less than Greenwich and is used throughout Newfoundland and Labrador.

ATLANTIC Standard Time, which is the local time at the 60th meridian (running near Sydney, Cape Breton), is four hours less than Greenwich and is used throughout Nova Scotia, Prince Edward Island, New Brunswick, and those parts of Quebec and the Northwest Territories east of the 68th meridian.

EASTERN Standard Time, which is the local time at the 75th meridian (running near Cornwall, Ontario), is five hours less than Greenwich and is used in Quebec west of the 68th meridian, in Ontario east of the 90th meridian, and in the Northwest Territories between the 68th and 85th meridians.

CENTRAL Standard Time, which is the local time at the 90th meridian, is six hours less than Greenwich and is used in Ontario west of the 90th meridian, in Manitoba, and in the Northwest Territories between the 85th and 102nd meridians.

MOUNTAIN Standard Time, which is the local time at the 105th meridian (running near Regina, Saskatchewan), is seven hours less than Greenwich and is used throughout Saskatchewan, Alberta, and in that part of the Northwest Territories between the 102nd and the 120th meridians.

PACIFIC Standard Time, which is the local time at the 120th meridian

(running near Kamloops, British Columbia), is eight hours less than Greenwich and is used throughout British Columbia and in that part of the Northwest Territories lying west of the 120th meridian.
YUKON Standard Time, which is the time at the 135th meridian (running near Whitehorse, Yukon Territory), is nine hours less than Greenwich and is used throughout Yukon Territory.

Near the boundaries of the zones, some municipalities adopt the time of the adjacent zone. There are also communities, particularly in the northern outposts, which adopt such time as seems best to suit their convenience. In general, however, the legal boundaries of the several time zones are actually in use.

Daylight Saving Time

It was not until the beginning of World War I that the adoption of daylight saving time was seriously considered, although propaganda had been carried on for some years previously. In 1916 an Act of Parliament legalized its use in Great Britain and since that time it has been maintained there. The United States adopted daylight saving over the entire country in 1918, and in 1919 its use there was fairly general. Since that time some states have legislated to continue its use, and many cities and towns, particularly in the eastern and central states, have done similarly.

In Canada the Dominion Government, by the Daylight Saving Act of 1918, required the adoption of daylight saving during the summer of that year. After 1918 the act lapsed.

During World War II there were three Orders-in-Council passed under the War Measures Act dealing with the observance of Daylight Saving Time:

(i) PC4494, 20 September, 1940, directed "that Daylight Saving Time, so called, (being one hour in advance of Standard Time) observed during the past summer months, shall continue to be observed until such time as the Governor-in-Council may otherwise order in the Province of Quebec and in the Province of Ontario by all persons, firms and corporations resident or carrying on business therein except transportation companies and telegraph companies."

(ii) PC547, 26 January, 1942, ordered that "as of and from 2.00 A.M. Standard Time, Monday, February 9th. 1942, until otherwise ordered, the time for all purposes in Canada shall be one hour in advance of accepted Standard Time, and that Daylight Saving Time shall be observed by all persons, firms, corporations and public authorities, without exception, situate, resident or carrying on business in Canada."

(iii) PC6102, 14 September, 1945, revoked the above.

Several provinces have legislation controlling provincial or municipal adoption (or rejection) of daylight saving. Elsewhere it is necessary to

refer to the individual municipalities to determine whether and between what dates daylight saving is adopted in any particular year.

A fact to which little attention is paid, is that the position of any city with reference to the standard meridian of its time zone has considerable bearing on the question of the adoption of daylight saving. For example, the standard meridian of the eastern standard time zone passes slightly east of Ottawa, and for Port Arthur, near the westerly boundary of the zone, this standard time is fifty-seven minutes faster than the local time, while for Rimouski, situated near the easterly boundary of the zone, standard time is twenty-six minutes slower than the local time. Daylight saving time would, therefore, be much more suitable for the place east of the standard meridian. In Canada the standard meridians are, in general, east of the centres of the time zones, so that for large areas of the country a species of "fast time" is being used all the year. North of the sixtieth parallel, during the ordinary period for the application of daylight saving, there is enough daylight to satisfy the most prodigal user so that daylight saving is not necessary there.

A list of the places in Canada using daylight saving time would require yearly revision. From information kindly furnished by the Railway Association of Canada, it is found that the following places used daylight saving in 1957 during the period April 28th to October 27th, with certain changes as noted.

CITIES, TOWNS AND MUNICIPALITIES IN CANADA ADOPTING DAYLIGHT SAVING TIME SUMMER 1957

Province of Newfoundland

Entire Province (Apr. 28–Sept. 29)

Province of Prince Edward Island

Not used.

Province of Nova Scotia

Amherst
Digby
Halifax
(Apr. 28–Sept. 29)
Liverpool
North Sydney
Sydney
Truro
(Apr. 28–Sept. 29)
Yarmouth
(Apr. 28–Sept. 29)

Province of New Brunswick

Bathurst
(Apr. 29–Sept. 30)
Campbellton
(Apr. 28–Sept. 1)
Chatham
(Apr. 27–Sept. 30)
Dalhousie
(Apr. 27–Sept. 29)
Fredericton
(Apr. 28–Sept. 29)
Moncton
Newcastle
Sackville
St. Andrews
Saint John
Sussex
Woodstock
(Apr. 28–Sept. 29)

Province of Quebec

Asbestos
Coaticook
Cowansville
Danville
Drummondville
Foster
Granby
Grand'Mère
Hull
Joliette
Jonquiere
La Tuque
Lennoxville
Levis
Magog
Montreal
Montreal West
Quebec
Richmond
St. Hyacinthe
St. Jerome
St. Johns
St. Lambert
Shawinigan Falls
Sorel
Thetford Mines
Trois Rivières
Valleyfield
Verdun
Westmount

Province of Ontario

Arnprior
Aurora
Belleville
Brampton
Brantford
Brockville
Burlington
Campbellford
Chatham
(Apr. 28–Sept. 1)
Cobalt
Cornwall
Etobicoke
Fort Erie
Goderich
Grimsby
Guelph
(Apr. 28–Sept. 29)
Huntsville
Ingersoll
Kenora
Kincardine
Kingston
Kirkland Lake
Kitchener
Lakefield
Leaside
London
Markham
Merritton
Midland
New Liskeard
Niagara Falls
Niagara-on-the-Lake
Oakville
Oshawa
Ottawa
Owen Sound
Paris
Pembroke
Penetanguishene
Peterborough
Port Colborne
Port Dalhousie
Port Hope
Prescott
Richmond Hill
St. Thomas
Sault Ste. Marie
(Apr. 28–Sept. 29)
Smiths Falls
Southampton
Stratford
Sudbury
Thorold
Tillsonburg
Timmins
Toronto
Trenton
Waterdown
Welland
Weston
Whitby
Woodbridge
Woodstock

Province of Manitoba

St. Boniface
(Apr. 28–Sept. 29)
Winnipeg
(Apr. 28–Sept. 29)

Province of Saskatchewan

Moose Jaw
(Apr. 28–Sept. 29)
Prince Albert
(Apr. 28–Sept. 29)
Regina
(Apr. 28–Sept. 29)
Saskatoon
Weyburn
(Apr. 28–Sept. 29)

Province of Alberta

Not used

Province of British Columbia

Entire Province (Apr. 28–Sept. 28)

Universal Time Chart

The universal time chart is for the purpose of finding the corresponding times at different places.

For those countries and places whose standard times differ by whole hours from Greenwich time, the chart gives an easy and reliable method of conversion.

At each standard meridian there is a vertical column of figures including all the hours of the day, a.m. and p.m. The outline map of the world superimposed on the chart suggests the standard time used at any place. The horizontal lines show the corresponding times.

Pick out any hour in that vertical column passing nearest to any particular place, follow the horizontal line to the column nearest to any other place required, and the corresponding time is obtained. A change of date occurs as the horizontal line crosses the diagonal line running from the upper right to the lower left corner, the date of those places lying to the right of the diagonal being one day later than that of those to the left.

Examples

(1) 4^h p.m. July 5 at Ottawa corresponds to
11^h a.m. July 5 at places in Alaska, to
9^h p.m. July 5 at Paris, and to
6^h a.m. July 6 at Tokyo.

(2) $3^h\ 15^m$ p.m. August 3 in Western Australia corresponds to
$7^h\ 15^m$ a.m. August 3 at Greenwich and to
$11^h\ 15^m$ p.m. August 2 at Vancouver.

Adopted Standard Times of the World

Deviations from the theoretical boundaries of standard time zones frequently occur. Also many locations observe a time which differs by something other than a whole number of hours from Greenwich. The following table, giving the times recognized in various regions, has been taken from the British Nautical Almanac.

Where daylight saving is used, the hours in the first column must be corrected by subtracting one hour for the interval during which daylight saving is in force.

STANDARD TIMES
(Corrected to March 1957)

LIST I—PLACES FAST ON G.M.T. (EAST OF GREENWICH)

The times given below should be { added to G. M.T. to give Standard Time. / subtracted from Standard Time to give G.M.T.

	h	m	s
Aden	03		
Admiralty Islands	10		
Albania	01		
Algeria	01		
Amirante Islands	04		
Andaman Islands	06	30	
Angola (Portuguese West Africa)	01		
Annobon Islands	01		
Australian Capital Territory	10		
Austria	01		
Bahrein	04		
Balearic Islands	01		
Basutoland	02		
Bechuanaland	02		
Belgian Congo (western part, including Coquilhatville and Leopoldville)	01		
(eastern part, including Costermansville, Elisabethville, Lusambo, and Stanleyville)	02		
Belgium	01		
British New Guinea	10		
British North Borneo	08		
British Somaliland	03		
Bulgaria	02		
Burma	06	30	
Cameroons	01		
Caroline Islands (east of long. E. 160°)	12		
(west of long. E. 160°)	10		
(Truk, Ponape)	11		
Ceylon	05	30	
Chagos Archipelago	05		
Chatham Islands	12	45	
China	08		
Christmas Island, Indian Ocean	07		
Cocos-Keeling Islands	06	30	
Comoro Islands	03		
Corsica	01		
Crete	02		
Cyprus	02		
Cyrenaica	02		
Czechoslovakia	01		
Dahomey (French W. Africa)	01		
Denmark	01		
Dutch New Guinea	09	30	
Egypt	02		
Ellice Islands	12		
Eritrea	03		
Estonia	03		
Fernando Po	01		
Fiji	12		
Finland	02		
Formosa	08		
France	01		
French Equatorial Africa	01		
French Somaliland	03		
Friendly Islands	12	20	
Germany	01		
Gibraltar	01		
Gilbert and Ellice Islands	12		
Greece	02		
Guam	10		
Gwadar	04	30	
Hainan Island, China	07		
Holland	01		
Hong Kong	08		
Hungary	01		
India	05	30	
Indo-China, Federation of: Cambodia	07		

LIST I—(continued)

	h	m	s
Laos	07		
Viet Nam	07		
Indonesia, United States of:			
North Sumatra, Mentawai Islands, Nias	06	30	
South Sumatra, Anambas Islands, Bangka, Belitong, Natuna Islands, Rhio Islands	07		
Borneo, Java, Bali, Lombok, Madura	07	30	
Celebes, Alor, Flores, Lomblem, Pantar, Roti, Sanghi Islands, Savu, Sumba, Sumbawa, Talaur Islands, Timor	08		
Moluccas (Buru, Serang (Ceram), Halmahera), Babar Islands, Sula Islands, Wetta	08	30	
Aru Islands, Kei Islands, Tanimbar Islands	09		
Iran (Persia)	03	30	
Iraq	03		
Israel	02		
Italy	01		
Japan	09		
Jappen Islands	09		
Jordan	02		
Kamchatka Peninsula	12		
Kenya	03		
Korea	08	30	
Kuril Islands	09		
Kuweit	03		
Labuan	08		
Laccadive Islands	05	30	
Ladrone Islands	10		
Latvia	03		
Lebanon	02		
Lichtenstein	01		
Lithuania	03		
Lord Howe Island	10		
Luxembourg	01		
Macao	08		
Madasgascar	03		
Malaya, Federation of	07	30	
Maldive Republic	05	05	
Malta	01		
Manchuria	09		
Mariana Islands	10		
Marshall Islands	12		
Mauritius	04		
Monaco	01		
Mozambique (Portuguese East Africa)	02		
Mukalla (Hadhramaut)	03		
Nanyo Gunto	09		
Nauru	11	30	
Netherlands, The	01		
New Caledonia	11		
New Guinea, British	10		
New Guinea, Dutch	09	30	
New Hebrides	11		
New South Wales	10		
(except Broken Hill area)	09	30	
New Zealand	12		
Nicobar Islands	06	30	
Nigeria	01		
Norfolk Island	11	30	
North Borneo	08		
Northern Rhodesia	02		
Northern Territory, Australia	09	30	
Norway	01		
Novaya Zemlya	05		
Nyasaland	02		
Ocean Island	11		
'Oman (Masira, Muscat and Salala)	04		
Pakhoi, China	07		
Pakistan (East)	06		
(West)	05		
Papua	10		
Pescadores Islands	08		
Philippine Republic	08		
Poland	01		

LIST I—(concluded)

	h	m	s
Portuguese East Africa (Mozambique)	02		
Portuguese India	05	30	
Queensland	10		
Réunion	04		
Rhodesia	02		
Romania	02		
Russia (west of long. E. 40°)	03		
(long. E. 40° to E. 52° 30′)	04		
(east of long. E. 52° 30′)	05		
Sakhalin (south of lat. N. 50°)	09		
(north of lat. N. 50°)	10		
Santa Cruz Islands	11		
Sarawak	08		
Sardinia	01		
Schouten Islands	09		
Seychelles	04		
Siam (Thailand)	07		
Siberia (west of long. E. 67° 30′)	05		
(long. E. 67°30′ to E.82°30′)	06		
(long. E.82°30′ to E.97°30′)	07		
(long. E.97°30′ to E.112° 30′)	08		
(long. E.112°30′ to E.127° 30′)	09		
(long. E.127°30′ to E.142° 30′)	10		
(long. E.142°30′ to E.157° 30′)	11		
(long. E.157°30′ to E.172° 30′)	12		
(east of long. E. 172°30′)	13		
Sicily	01		
Singapore	07	30	
Socotra	03		
Solomon Islands	11		
Somalia	03		
Somaliland	03		
South Africa, Union of	02		
South Australia	09	30	
Southern Rhodesia	02		
Spain	01		
Spanish Guinea	01		
Spitzbergen	01		
Sudan, Republic of	02		
Swaziland	02		
Sweden	01		
Switzerland	01		
Syria	02		
Tanganyika Territory	03		
Tasmania	10		
Thailand (Siam)	07		
Timor	08		
Tonga Islands	12	20	
Transjordan (Jordan)	02		
Tripolitania	02		
Trucial 'Oman (Sharja)	04		
Truk	11		
Tunisia	01		
Turkey	02		
Uganda	03		
Union of South Africa	02		
Victoria	10		
Western Australia	08		
Wrangell Island	13		
Yugoslavia	01		
Zanzibar	03		

LIST II—PLACES NORMALLY KEEPING G.M.T.

Ascension Island	Gambia	Morocco	São Thomé
Canary Islands	Ghana	Portugal	Sierra Leone
Channel Islands	Great Britain	Principe	Tangier
Faeroes, The	Ireland, Northern	Rio de Oro	Togoland (French)
French West Africa	Irish Republic	St. Helena	Tristan Da Cunha

LIST III—PLACES SLOW ON G.M.T. (WEST OF GREENWICH)

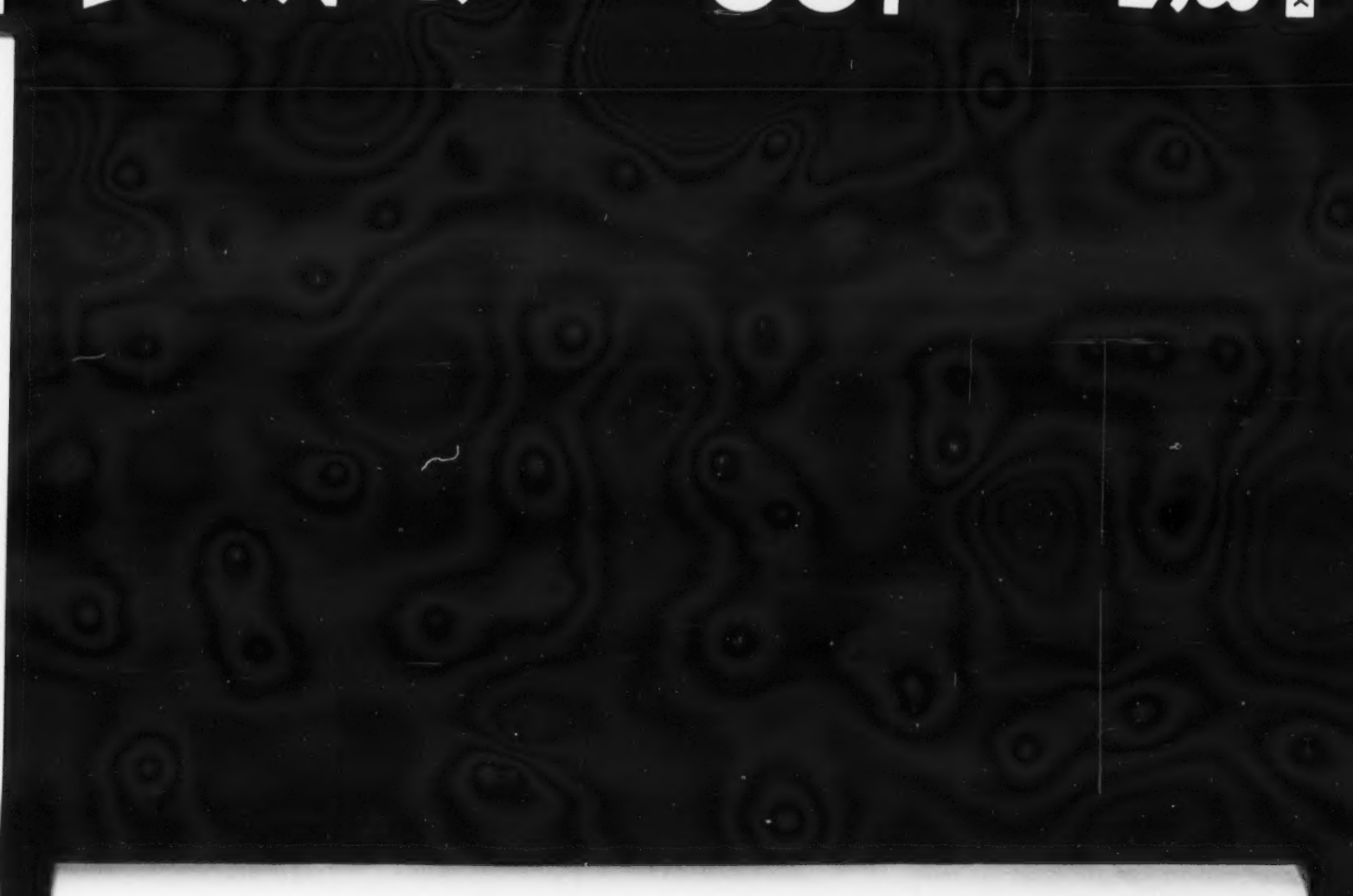
The times given below should be { subtracted from G.M.T. to give Standard Time. / added to Standard Time to give G.M.T.

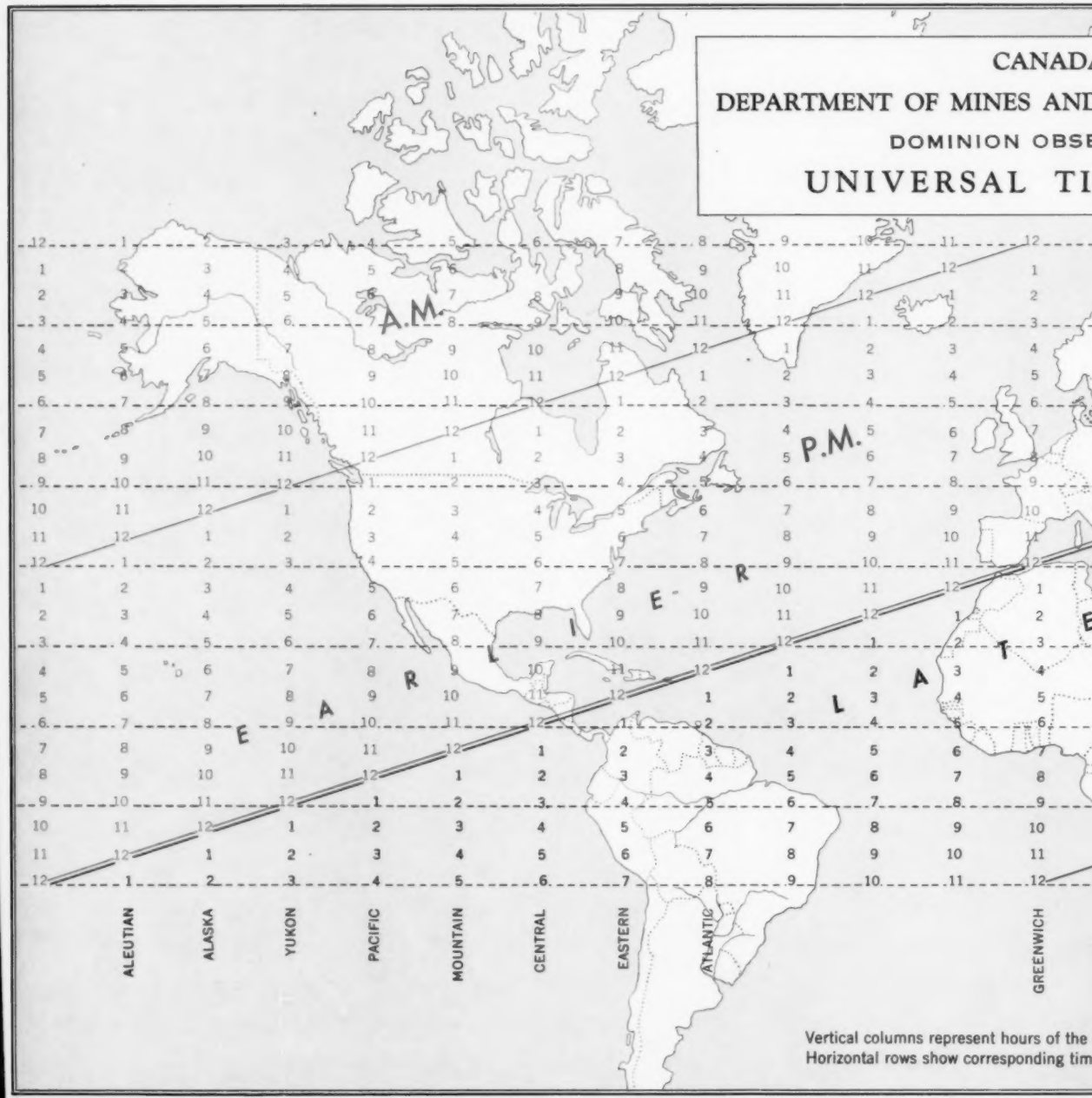
	h	m	s
Alabama, U.S.A.	06		
Alaska, south-east coast to and including Cross Sound, Douglas, Juneau, Kimsham Cove and Petersburg	08		
coast northward of Cross Sound to long. W. 141°	09		
long. W. 141° to W. 162°, including Anchorage, Fairbanks, Seward, Valdez	10		
west coast (Nome)	11		
Alberta	07		
Aleutian Islands	11		
Argentina	03		
Arizona, U.S.A.	07		
Arkansas, U.S.A.	06		
Austral Islands	10		
Azores	02		
Bahamas	05		
Barbados	04		
Bermuda	04		
Bolivia	04		
Brazil (Central)	04		
(Eastern)	03		
(Western)	05		
British Columbia	08		
British Guiana	03	45	
British Honduras	06		
California, U.S.A.	08		
Canada (see provinces)	03 30 to 09[h]		
Cape Verde Islands	02		
Cayman Islands	05		
Chile	04		
Christmas Islands (Gilbert and Ellice)	10		
Colombia	05		
Colorado, U.S.A.	07		
Connecticut, U.S.A.	05		
Cook Islands (except Niue)	10	30	
Costa Rica	06		

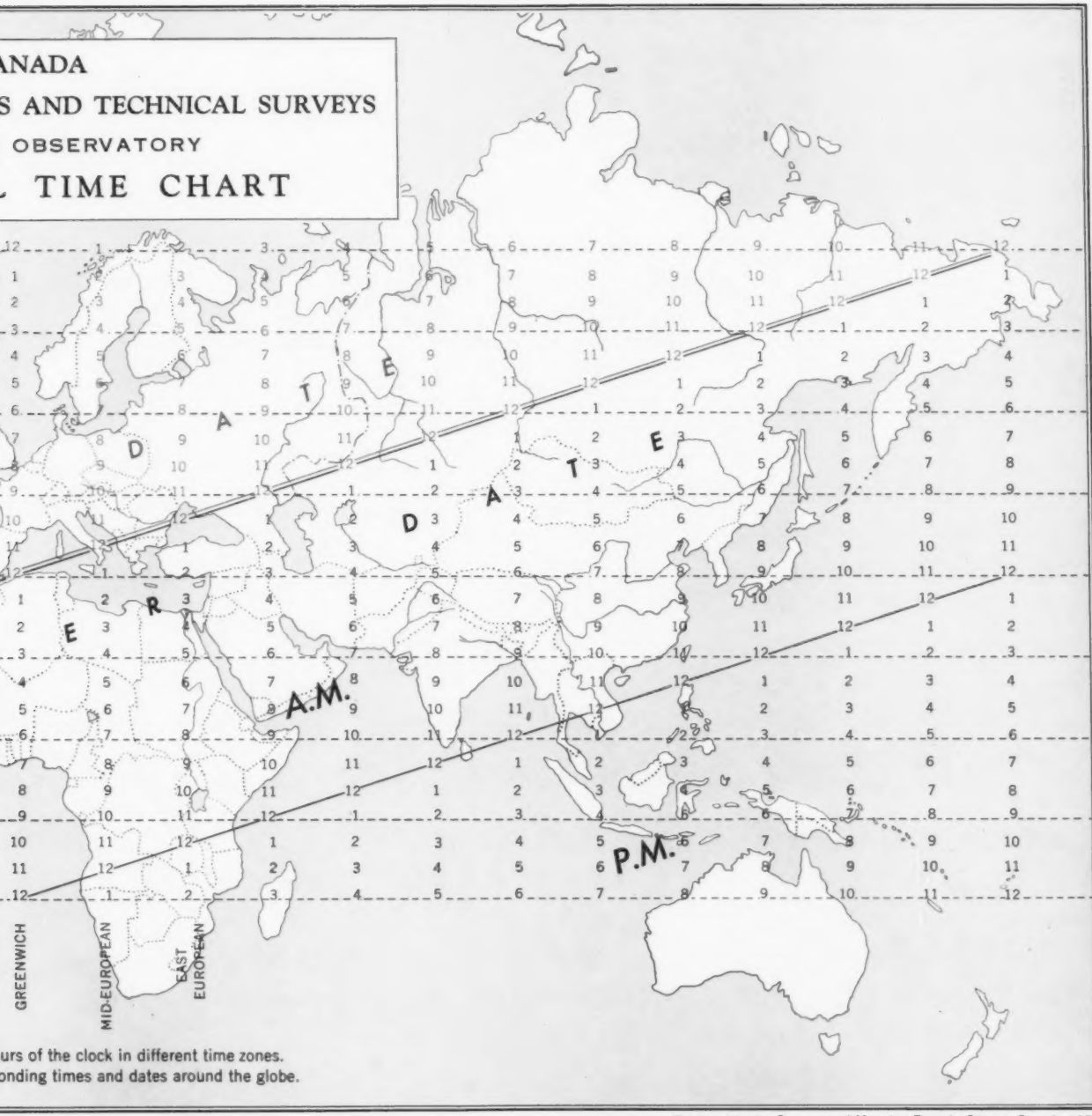
	h	m	s
Cuba	05		
Curaçao Island	04	30	
Delaware, U.S.A.	05		
Dominican Republic	05		
Dutch Guiana (Surinam)	03	30	
Ecuador	05		
Falkland Islands	04		
Fanning Island	10		
Fernando Noronha	02		
Florida, U.S.A.	05		
French Guiana	04		
Georgia, U.S.A.	05		
Greenland, Scoresby Sound	02		
Angmagssalik and W. coast	03		
Thule area	04		
Grenada	04		
Guadeloupe	04		
Guatemala	06		
Guiana, British	03	45	
Dutch	03	30	
French	04		
Haiti	05		
Hawaiian Islands (except Midway Island)	10		
Honduras	06		
Honduras, British	06		
Iceland	01		
Idaho, U.S.A.	07		
Illinois, U.S.A.	06		
Indiana, U.S.A.	06		
Iowa, U.S.A.	06		
Jamaica	05		
Johnston Island	11		
Kansas, U.S.A.	06		
Kentucky, U.S.A.	06		

LIST III—(continued)

	h	m	s
Labrador	03	30	
Leeward Islands	04		
Liberia	00	44	30
Louisiana, U.S.A.	06		
Low Archipelago	10		
Madeira	01		
Maine, U.S.A.	05		
Manitoba	06		
Marquesas Islands	10		
Martinique	04		
Maryland, U.S.A.	05		
Massachusetts, U.S.A.	05		
Mexico	06		
(except the states of Sonora, Sinaloa, Nayarit, and S. District of Lower California which keep)	07		
(and Northern District of Lower California which keeps)	08		
Michigan, U.S.A.	05		
Midway Islands	11		
Minnesota, U.S.A.	06		
Miquelon	04		
Mississippi, U.S.A.	06		
Missouri, U.S.A.	06		
Montana, U.S.A.	07		
Nebraska, U.S.A. (eastern part)	06		
(western part)	07		
Nevada, U.S.A.	08		
New Brunswick	04		
Newfoundland	03	30	
New Hampshire, U.S.A.	05		
New Jersey, U.S.A.	05		
New Mexico, U.S.A.	07		
New York, U.S.A.	05		
Nicaragua	06		
Niue Island	11	20	
North Carolina, U.S.A.	05		
North Dakota, U.S.A.	06		
Northwest Territories			
(east of long. W.68°)	04		
(long. W.68° to W.85°)	05		
(long. W.85° to W.102°)	06		
(long. W.102° to W.120°)	07		
(west of long. W.120°)	08		
Nova Scotia	04		
Ohio, U.S.A.	05		
Oklahoma, U.S.A.	06		
Ontario (east of long. W.90°)	05		
(west of long. W.90°)	06		
Oregon, U.S.A.	08		
Panama Canal Zone	05		
Panama (Republic of)	05		
Paraguay	04		
Pennsylvania, U.S.A.	05		
Peru	05		
Portuguese Guinea	01		
Prince Edward Island	04		
Puerto Rico	04		
Quebec (east of long. W.68°)	04		
(west of long. W.68°)	05		
Rarotonga	10	30	
Rhode Island, U.S.A.	05		
St. Pierre and Miquelon	04		
Salvador	06		
Samoa	11		
Saskatchewan	07		
Savage Island	11	20	
Scoresby Sound, Greenland	02		
Society Islands	10		
South Carolina, U.S.A.	05		
South Dakota, U.S.A. (eastern part)	06		
(western part)	07		
South Georgia	02		
Surinam (Dutch Guiana)	03	30	
Tennessee, U.S.A.	06		
Texas, U.S.A.	06		
Tobago	04		
Trinidad	04		
Trinidad Islands, S. Atlantic	02		
Tuamotu Archipelago	10		
Tubuai Islands	10		

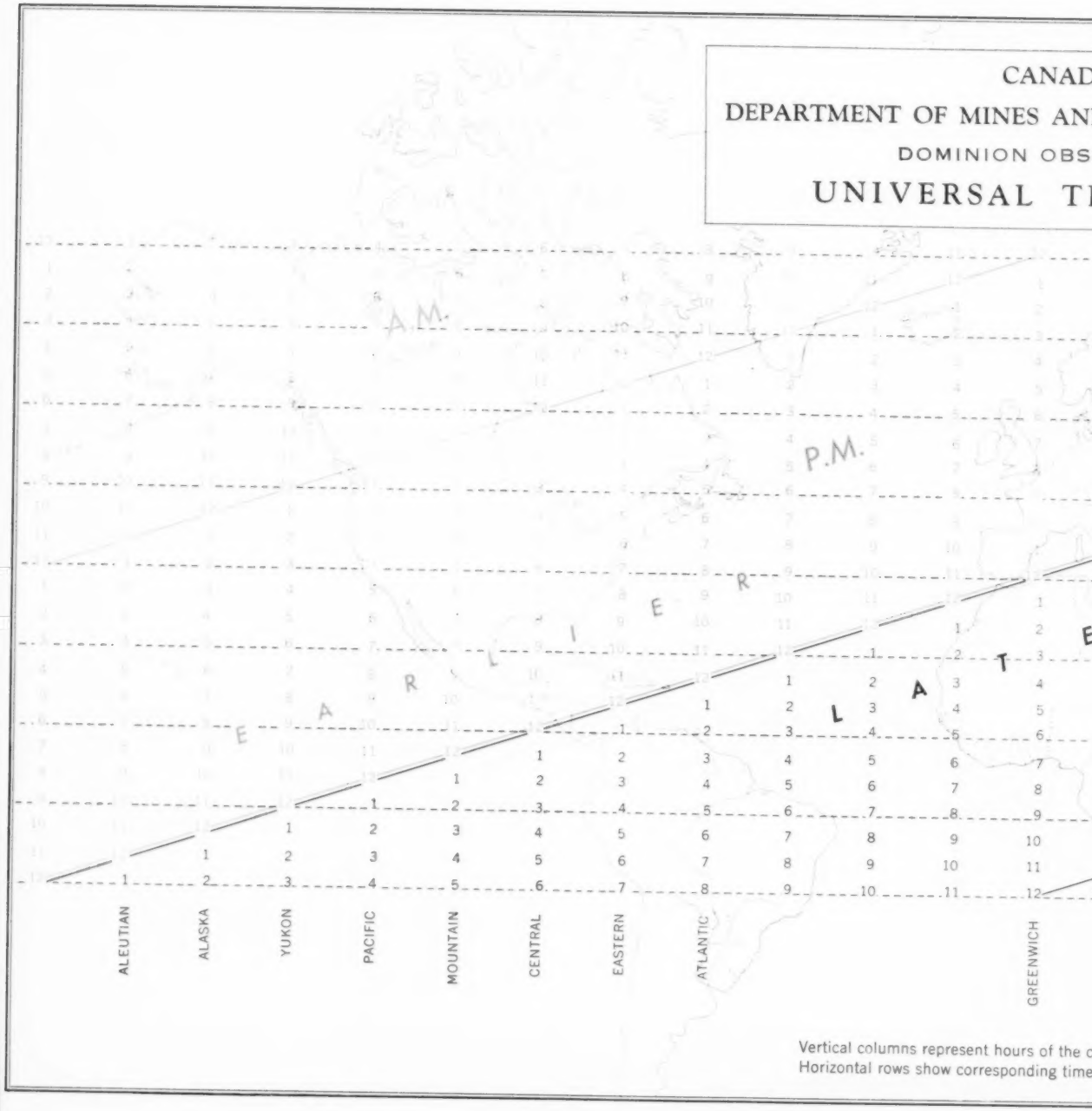


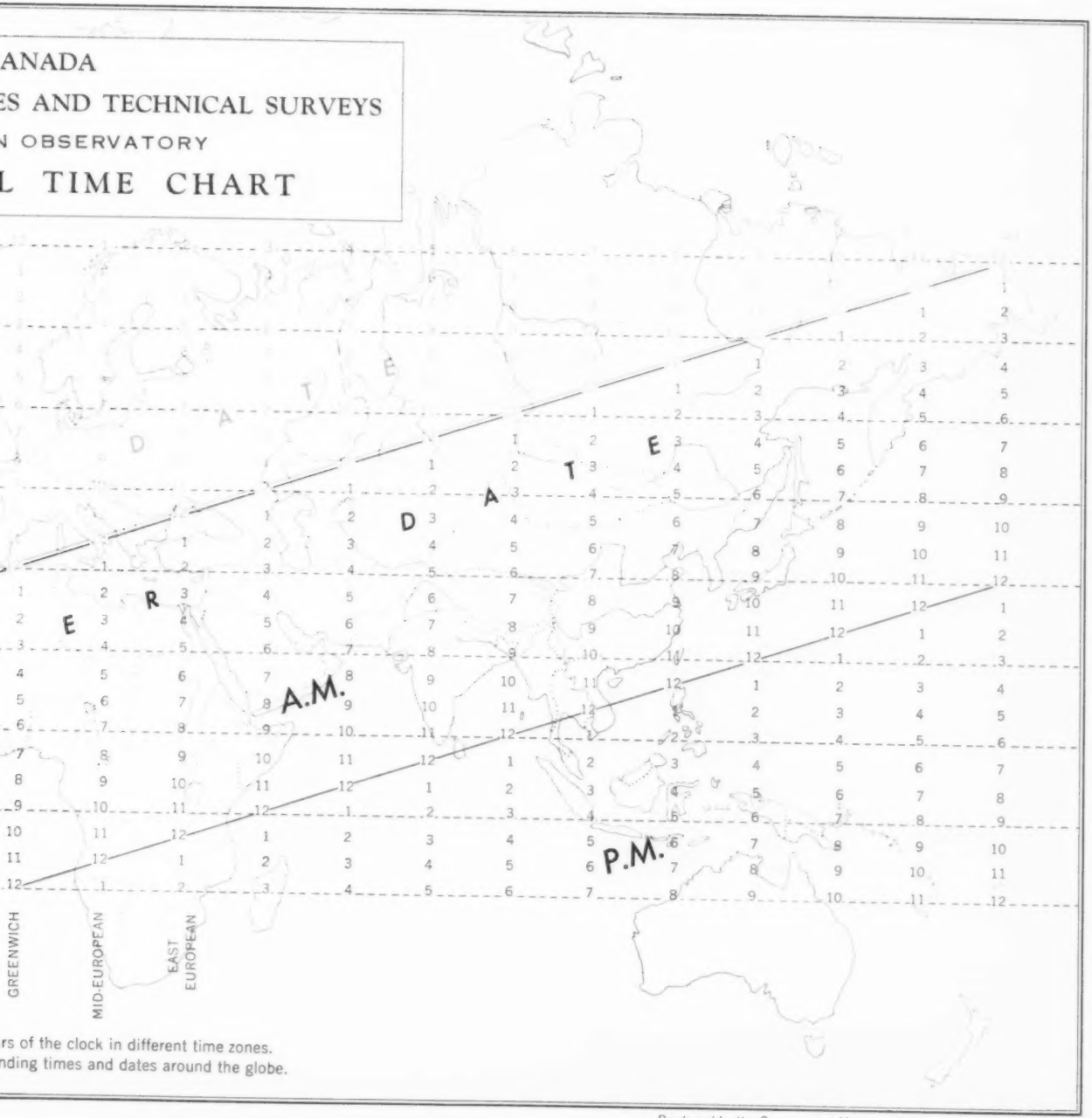

CANADA
DEPARTMENT OF MINES AND
DOMINION OBSE
UNIVERSAL TI
A.M.
P.M.
EARLIER
LATER
ALEUTIAN
ALASKA
YUKON
PACIFIC
MOUNTAIN
CENTRAL
EASTERN
ATLANTIC
GREENWICH
Vertical columns represent hours of the
Horizontal rows show corresponding tim



urs of the clock in different time zones.
onding times and dates around the globe.

Produced by the Surveys and Mapping Branch, Ottawa, Canada 1958


CANAD
DEPARTMENT OF MINES AN
DOMINION OBS
UNIVERSAL TI
A.M.
P.M.
E A R L I E R
L A T E
ALEUTIAN
ALASKA
YUKON
PACIFIC
MOUNTAIN
CENTRAL
EASTERN
ATLANTIC
GREENWICH
Vertical columns represent hours of the
Horizontal rows show corresponding time



rs of the clock in different time zones.
nding times and dates around the globe.

Produced by the Surveys and Mapping Branch, Ottawa, Canada 1958

LIST III—(concluded)

	h	m	s		h	m	s
Uruguay	03			Washington, U.S.A.	08		
Utah, U.S.A.	07			West Virginia, U.S.A.	05		
				Windward Islands	04		
Venezuela	04	30		Wisconsin, U.S.A.	06		
Vermont, U.S.A.	05			Wyoming, U.S.A.	07		
Virginia, U.S.A.	05						
				Yukon	09		
Washington, D.C., U.S.A.	05						

Sunrise and Sunset

The time of sunrise or sunset is defined as the time when the true zenith distance of the sun's centre is 90° 50′. This is the time when the upper edge of the sun's disc appears or disappears on a level plain, allowing 34′ for refraction and 16′ for the semi-diameter of the sun.

Table I gives the latitude and the correction from local to standard time for 166 places in Canada. The abbreviations N, A, E, C, M, and P are used for Newfoundland, Atlantic, Eastern, Central, Mountain and Pacific standard times respectively. Thus for St. John, N.B., the nearest degree of latitude is 45°, and a correction of +24 minutes to local time is required to reduce to Atlantic standard time. Had it been required to obtain Eastern standard time the correction would obviously have been −36 minutes.

Table II gives the local times of sunrise and sunset for every fifth day for latitudes 40° to 70°. These have been extracted from "Tables of Sunrise and Sunset and Twilight", Supplement to the American Ephemeris 1946. They have been computed for longitude 90° West and for the year 1966, and for most ordinary purposes may be used directly.

With the latitude obtained from Table I (using that given for the nearest place), the local time of sunrise or sunset for the date required can be taken from Table II. The time correction obtained from Table I and applied to this local time gives approximately the required standard time.

Example 1. To find the approximate times of sunrise and sunset at Pembroke, Ontario, on September 1. From Table I the latitude is 46° and the correction to be applied to get eastern standard time is +8 minutes. From Table II the local times of sunrise and sunset for latitude 46° on September 1 are 5 hours 19 minutes and 18 hours 40 minutes, respectively. The approximate standard times are, therefore, 5 hours 27 minutes and 18 hours 48 minutes.

Example 2. To find the approximate times of sunrise and sunset at Guelph, Ontario, on July 1. For Hamilton (the nearest place given in Table I) the latitude is 43° and

the correction to reduce to eastern standard time is +20 minutes. From Table II the local times are by interpolation 4 hours 24 minutes and 19 hours 43 minutes, and hence 4 hours 44 minutes and 20 hours 3 minutes are the approximate standard times.

For places not given in Table II the latitude and local time correction can, of course, be easily obtained from a map or otherwise, and the times of sunrise and sunset obtained.

If a more accurate determination of sunrise or sunset is required for a particular year, reference may be made to Tables III and IV for corrections which may be applied to values derived from Table II to compensate for the year and the longitude. In Table II one may note that the time of sunrise or of sunset changes from day to day. The factor obtained from Tables III and IV is multiplied by this daily rate of change for the date involved.

Example 3. Find the zone or mountain standard time of sunrise and sunset at Edmonton, Alberta, 113° 29′ W, 53° 32′ N, on April 1, 1956.

i. Correction factor for 113°.5 W and 1956 is 0.17 + 0.32 = 0.49

ii. Local time of sunrise at Edmonton April 1, 1956:

Table II. April 1 at 52°N yields	05^h36^m
Daily rate -2^m × factor of 0.49 yields correction	-1^m
Sunrise at 52°N =	05^h35^m
Table II. April 1 at 54°N yields	05^h34^m
Daily rate -2^m × factor of 0.49 yields correction	-1^m
Sunrise at 54°N =	05^h33^m

Interpolating for 53°32′N, the latitude of Edmonton, yields
$05^h35^m - 2^m \times 1.53/2 = 05^h33^m$ the local time of sunrise

iii. Local time of sunset at Edmonton April 1, 1956:

Table II. April 1 at 52°N yields	18^h33^m
Daily rate $+2^m$ × factor of 0.49 yields correction	$+1^m$
Sunset at 52°N =	18^h34^m
Table II. April I at 54°N yields	18^h36^m
Daily rate $+2^m$ × factor of 0.49 yields correction	$+1^m$
Sunset at 54°N =	18^h37^m

Interpolating for 53°32′N, the latitude of Edmonton, yields
$18^h34^m + 3^m \times 1.53/2 = 18^h36^m$ the local time of sunset.

From Table I, the correction from local mean time to zone time at Edmonton is +34 minutes. Hence the mountain standard times of sunrise and sunset at Edmonton April 1, 1956, are $06^h\ 07^m$ and $19^h\ 10^m$ respectively.

TABLE I

LATITUDES AND QUANTITIES FOR REDUCTION FROM LOCAL TO STANDARD TIME

	Lat. Min.		Lat. Min.
Newfoundland		Carbonear	48 + 3 N
(Note: Zone time of Newfoundland is $3\frac{1}{2}$ hours slower than Greenwich)		Corner Brook	49 +22 N
		Gander	49 + 8 N
Argentia	47° + 6 N	Goose Bay	53 + 2 A
Buchans	49 +18 N	Grand Bank	47 +13 N

TABLE I—(continued)

	Lat.	Min.	
Grand Falls	49	+13	N
Lewisport	49	+10	N
St. Anthony	51	+12	N
St. John's	48	+ 1	N
Twillingate	50	+ 9	N
Nova Scotia			
Amherst	46°	+17	A
Annapolis	45	+22	A
Antigonish	46	+ 8	A
Canso	45	+ 4	A
Digby	45	+23	A
Glace Bay	46	0	A
Halifax	45	+14	A
Lunenburg	44	+17	A
Mulgrave	46	+ 6	A
Pictou	46	+11	A
Shelburne	44	+21	A
Sydney	46	+ 1	A
Truro	45	+13	A
Yarmouth	44	+24	A
New Brunswick			
Bathurst	48°	+23	A
Boiestown	46	+26	A
Campbellton	48	+27	A
Chatham	47	+22	A
Edmundston	47	+33	A
Fredericton	46	+27	A
Moncton	46	+19	A
Richibucto	47	+20	A
St. Andrews	45	+28	A
St. John	45	+24	A
Shediac	46	+18	A
Shippigan	48	+19	A
Woodstock	46	+30	A
Prince Edward Island			
Charlottetown	46°	+12	A
Georgetown	46	+11	A
Tignish	47	+16	A
Quebec			
Calumet	46°	− 1	E
Doucet	48	+ 6	E
Eskimo Point	50	+15	A
Farnham	45	− 8	E
Gatineau River Forks	47	+ 1	E
Grand'Mère	47	− 9	E
Harricanaw	49	+12	E
Harrington Harbour	51	− 2	A
Hull	45	+ 3	E
Knowlton	45	−10	E
Lachute	46	− 3	E
L'Islet	47	−19	E
Maniwaki	46	+ 4	E
Matane	49	+30	A
Megantic	46	−16	E
Montreal	46	− 6	E
Murray Bay	48	−19	E
Natashkwan	50	+ 7	A
New Carlisle	48	+21	A
Percé	49	+17	A
Quebec	47	−15	E
Roberval	48	−11	E
St. Augustin River	51	− 5	A
St. Hyacinthe	46	− 8	E
Sept Iles	50	+26	A
Sherbrooke	45	−12	E
Sorel	46	− 8	E
Tadoussac	48	−21	A
Three Rivers	46	−10	E
Valleyfield	45	− 3	E
Ontario			
Arnprior	45°	+ 5	E
Barrie	44	+19	E
Belleville	44	+ 9	E
Brantford	43	+21	E
Brockville	45	+ 3	E
Chapleau	48	+34	E
Cornwall	45	− 1	E
Fort William	48	+57	E
Hamilton	43	+20	E
Kenora	50	+18	C
Kingston	44	+ 6	E
London	43	+25	E
Matheson	49	+22	E
New Liskeard	48	+19	E
Niagara Falls	43	+16	E
North Bay	46	+18	E
Orillia	45	+18	E

TABLE I—(concluded)

	Lat.	Min.
Ottawa	45	+ 3 E
Owen Sound	45	+24 E
Port Arthur	48	+57 E
Pembroke	46	+ 8 E
Peterborough	44	+13 E
Port Colborne	43	+17 E
Rainy River	48	+18 C
Renfrew	45	+ 7 E
Rondeau	42	+28 E
Sarnia	43	+29 E
Sault Ste. Marie	47	+37 E
Stratford	43	+24 E
Sudbury	47	+24 E
Toronto	44	+18 E
Windsor	42	+32 E
Manitoba		
Birtle	50°	+44 C
Brandon	50	+40 C
Carman	50	+32 C
Cartwright	49	+37 C
Dauphin	51	+40 C
Emerson	49	+29 C
Gimli	51	+28 C
Killarney	49	+39 C
Neepawa	50	+38 C
Oak Point	51	+32 C
Portage la Prairie	50	+33 C
Selkirk	50	+28 C
The Pas	54	+45 C
Winnipeg	50	+29 C
Saskatchewan		
Battleford	53°	+13 M
Biggar	52	+12 M
Estevan	49	− 8 M
Hudson Bay Jct.	53	−11 M
Indian Head	50	− 5 M
Maple Creek	50	+18 M
Lloydminster	53	+20 M
Melville	51	− 9 M
Moosejaw	50	+ 2 M
Mortlach	50	+ 4 M
North Portal	49	−10 M
Prince Albert	53	+ 3 M
Qu'Appelle	51	− 4 M
Regina	50	− 2 M
Saskatoon	52	+ 7 M
Swift Current	50	+11 M
Weyburn	50	− 5 M
Alberta		
Athabasca	55°	+33 M
Banff	51	+42 M
Blairmore	50	+38 M
Calgary	51	+36 M
Coronation	52	+26 M
Edmonton	54	+34 M
Exshaw	51	+41 M
Grande Prairie	55	+55 M
Jasper	53	+52 M
Lac la Biche	55	+28 M
Lethbridge	50	+31 M
Medicine Hat	50	+23 M
Red Deer	52	+35 M
Spirit River	56	+56 M
Wetaskiwin	53	+33 M
British Columbia		
Agassiz	49°	+ 7 P
Ashcroft	51	+ 5 P
Banfield	49	+21 P
Campbell River	50	+21 P
Chilliwack	49	+ 8 P
Esquimalt	48	+14 P
Fernie	50	−20 P
Grand Forks	49	− 6 P
Kamloops	51	+ 1 P
Lillooet	51	+ 8 P
Nanaimo	49	+16 P
Ocean Falls	52	+31 P
Prince Rupert	54	+41 P
Revelstoke	51	− 7 P
Vancouver	49	+12 P
Victoria	48	+13 P

TABLE II

LOCAL TIME OF SUNRISE AND SUNSET

Lat.	40°		42°		44°		46°		48°		50°		52°		54°	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set
Jan.																
1	0722	1645	0728	1639	0735	1633	0742	1625	0750	1617	0759	1609	0808	1559	0819	1548
6	0722	1650	0728	1644	0735	1637	0742	1630	0749	1623	0758	1614	0807	1605	0818	1555
11	0722	1655	0727	1649	0734	1643	0740	1636	0748	1629	0756	1621	0804	1612	0814	1602
16	0720	1700	0725	1655	0731	1649	0738	1642	0745	1636	0752	1628	0801	1620	0810	1610
21	0717	1706	0722	1701	0728	1655	0734	1649	0741	1643	0748	1636	0755	1628	0804	1619
26	0714	1712	0719	1707	0724	1702	0730	1656	0736	1650	0742	1644	0749	1637	0757	1629
31	0710	1718	0714	1713	0719	1709	0724	1704	0729	1658	0735	1652	0742	1646	0749	1639
Feb.																
5	0705	1724	0709	1720	0713	1716	0718	1711	0723	1706	0728	1701	0734	1655	0740	1649
10	0659	1730	0703	1726	0707	1722	0711	1718	0715	1714	0720	1709	0725	1704	0731	1659
15	0653	1736	0656	1733	0700	1729	0703	1726	0707	1722	0711	1718	0716	1714	0721	1709
20	0647	1741	0649	1739	0652	1736	0655	1733	0658	1730	0702	1727	0706	1723	0710	1719
25	0640	1747	0642	1745	0644	1743	0647	1740	0649	1738	0652	1735	0655	1732	0659	1729
Mar.																
2	0632	1753	0634	1751	0636	1749	0638	1748	0640	1746	0642	1743	0644	1741	0647	1739
7	0625	1758	0626	1757	0627	1756	0629	1755	0630	1753	0632	1752	0633	1750	0635	1748
12	0617	1804	0618	1803	0618	1802	0619	1801	0620	1801	0621	1800	0622	1759	0623	1758
17	0609	1809	0609	1809	0609	1808	0610	1808	0610	1808	0610	1808	0610	1808	0611	1807
22	0601	1814	0601	1814	0600	1815	0600	1815	0600	1815	0559	1816	0559	1816	0558	1817
27	0553	1819	0552	1820	0551	1821	0550	1822	0549	1823	0548	1824	0547	1825	0546	1826
Apr.																
1	0545	1824	0543	1825	0542	1827	0541	1828	0539	1830	0537	1832	0536	1833	0534	1836
6	0537	1829	0535	1831	0533	1833	0531	1835	0529	1837	0527	1839	0524	1842	0521	1845
11	0529	1834	0527	1836	0524	1839	0522	1841	0519	1844	0516	1847	0513	1851	0509	1854
16	0521	1839	0519	1842	0516	1845	0513	1848	0509	1851	0506	1855	0502	1859	0458	1903
21	0514	1844	0511	1848	0507	1851	0504	1855	0500	1859	0456	1903	0451	1908	0446	1913
26	0507	1849	0503	1853	0500	1857	0455	1901	0451	1906	0446	1911	0441	1916	0435	1922
May																
1	0500	1854	0456	1858	0452	1903	0447	1908	0442	1913	0437	1918	0431	1924	0424	1931
6	0454	1859	0450	1904	0445	1909	0440	1914	0434	1920	0428	1926	0422	1933	0414	1940
11	0449	1904	0444	1909	0439	1915	0433	1920	0427	1927	0420	1933	0413	1941	0405	1949
16	0444	1909	0439	1914	0433	1920	0427	1926	0420	1933	0413	1940	0405	1949	0356	1958
21	0440	1914	0434	1919	0428	1925	0422	1932	0415	1939	0407	1947	0358	1956	0348	2006
26	0436	1918	0431	1924	0424	1930	0417	1937	0410	1945	0401	1953	0352	2003	0342	2013
31	0434	1922	0428	1928	0421	1935	0414	1942	0406	1950	0357	1959	0347	2009	0336	2020
June																
5	0432	1925	0425	1932	0418	1939	0411	1946	0403	1955	0353	2004	0343	2014	0332	2026
10	0431	1928	0424	1935	0417	1942	0409	1950	0401	1958	0351	2008	0341	2018	0329	2031
15	0430	1930	0424	1937	0416	1944	0409	1952	0400	2001	0350	2011	0339	2022	0327	2034
20	0431	1932	0424	1939	0417	1946	0409	1954	0400	2003	0350	2013	0339	2023	0327	2036
25	0432	1933	0425	1940	0418	1947	0410	1955	0401	2004	0352	2013	0341	2024	0328	2036
30	0434	1933	0427	1940	0420	1947	0412	1955	0404	2003	0354	2013	0343	2024	0331	2036.

TABLE II—(continued)
LOCAL TIME OF SUNRISE AND SUNSET

Lat.	40°		42°		44°		46°		48°		50°		52°		54°	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set
July																
5	0437	1932	0430	1939	0423	1946	0415	1953	0407	2002	0358	2011	0347	2021	0335	2033
10	0440	1930	0433	1937	0427	1944	0419	1951	0411	1959	0402	2008	0352	2018	0340	2029
15	0443	1928	0437	1934	0431	1941	0424	1948	0416	1956	0407	2004	0357	2014	0347	2024
20	0447	1925	0441	1931	0435	1937	0428	1944	0421	1951	0413	1959	0404	2008	0354	2018
25	0452	1921	0446	1926	0440	1932	0434	1938	0427	1945	0419	1953	0411	2001	0401	2011
30	0456	1916	0451	1921	0446	1927	0440	1932	0433	1939	0426	1946	0418	1954	0409	2002
Aug.																
4	0501	1911	0456	1915	0451	1920	0446	1926	0440	1932	0433	1938	0426	1945	0418	1953
9	0505	1905	0501	1909	0457	1914	0452	1919	0446	1924	0440	1930	0434	1936	0427	1943
14	0510	1858	0506	1902	0502	1906	0458	1911	0453	1916	0448	1921	0442	1926	0435	1933
19	0515	1852	0512	1855	0508	1859	0504	1902	0500	1907	0455	1911	0450	1916	0444	1922
24	0520	1844	0517	1847	0514	1850	0510	1854	0506	1857	0502	1901	0458	1906	0453	1910
29	0524	1837	0522	1839	0519	1842	0516	1845	0513	1848	0510	1851	0506	1854	0502	1858
Sept.																
3	0529	1829	0527	1831	0525	1833	0523	1835	0520	1838	0517	1840	0514	1843	0511	1847
8	0534	1821	0532	1822	0531	1824	0529	1826	0527	1828	0525	1830	0523	1832	0520	1834
13	0539	1813	0538	1814	0536	1815	0535	1816	0534	1817	0532	1819	0531	1820	0529	1822
18	0543	1804	0543	1805	0542	1806	0541	1806	0541	1807	0540	1808	0539	1808	0538	1809
23	0548	1756	0548	1756	0548	1756	0548	1756	0548	1756	0547	1757	0547	1757	0547	1757
28	0553	1748	0553	1747	0554	1747	0554	1747	0555	1746	0555	1746	0555	1745	0556	1745
Oct.																
3	0558	1740	0559	1739	0600	1738	0601	1737	0601	1736	0603	1735	0604	1734	0605	1732
8	0603	1732	0604	1730	0606	1729	0607	1727	0609	1726	0610	1724	0612	1722	0614	1720
13	0608	1724	0610	1722	0612	1720	0614	1718	0616	1716	0618	1714	0621	1711	0624	1708
18	0613	1717	0616	1714	0618	1712	0620	1709	0623	1707	0626	1704	0629	1700	0633	1657
23	0619	1710	0621	1707	0624	1704	0627	1701	0631	1657	0634	1654	0638	1650	0643	1645
28	0624	1703	0627	1700	0631	1656	0634	1653	0638	1649	0643	1644	0647	1640	0652	1635
Nov.																
2	0630	1657	0634	1653	0637	1649	0642	1645	0646	1641	0651	1636	0656	1630	0702	1624
7	0636	1651	0640	1647	0644	1643	0649	1638	0654	1633	0659	1628	0705	1622	0712	1615
12	0641	1647	0646	1642	0651	1637	0656	1632	0701	1626	0708	1620	0714	1614	0722	1606
17	0647	1642	0652	1638	0657	1632	0703	1627	0709	1621	0716	1614	0723	1606	0731	1558
22	0653	1639	0658	1634	0704	1628	0710	1622	0716	1616	0724	1608	0731	1600	0740	1552
27	0658	1637	0704	1631	0710	1625	0716	1619	0723	1612	0731	1604	0739	1555	0749	1546
Dec.																
2	0703	1635	0709	1629	0716	1623	0722	1616	0730	1609	0738	1601	0747	1552	0757	1542
7	0708	1635	0714	1629	0721	1622	0728	1615	0736	1607	0744	1559	0753	1549	0804	1539
12	0712	1635	0719	1629	0725	1622	0733	1615	0740	1607	0749	1558	0759	1548	0810	1538
17	0716	1636	0722	1630	0729	1623	0736	1616	0745	1608	0753	1559	0803	1549	0814	1538
22	0718	1638	0724	1631	0731	1624	0739	1617	0747	1609	0756	1600	0806	1550	0817	1539
27	0721	1641	0727	1635	0734	1628	0741	1621	0749	1613	0758	1604	0808	1554	0819	1543
31	0722	1644	0728	1638	0735	1631	0742	1624	0750	1616	0759	1608	0808	1558	0819	1547

TABLE II—(continued)
LOCAL TIME OF SUNRISE AND SUNSET

Lat.	56°		58°		60°		62°		64°		66°		68°		70°	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set
Jan.																
1	0831	1536	0846	1522	0902	1505	0923	1444	0950	1418	1028	1339	■■	■■	■■	■■
6	0829	1543	0843	1529	0859	1513	0919	1454	0944	1429	1018	1354	1123	1249	■■	■■
11	0826	1551	0839	1538	0854	1523	0912	1505	0935	1442	1005	1411	1054	1323	■■	■■
16	0820	1600	0833	1548	0847	1534	0903	1517	0924	1457	0951	1430	1029	1351	■■	■■
21	0814	1610	0825	1558	0838	1546	0853	1531	0911	1512	0935	1449	1006	1417	1058	1326
26	0806	1620	0816	1610	0828	1558	0841	1545	0858	1528	0918	1508	0944	1442	1022	1404
31	0757	1631	0806	1621	0817	1611	0829	1559	0843	1545	0901	1528	0923	1506	0952	1436
Feb.																
5	0748	1641	0756	1633	0805	1624	0815	1614	0828	1601	0843	1547	0901	1528	0925	1505
10	0737	1652	0744	1645	0752	1638	0801	1628	0812	1618	0825	1605	0840	1550	0859	1531
15	0726	1703	0732	1657	0739	1651	0747	1643	0756	1634	0806	1624	0819	1611	0835	1555
20	0714	1714	0719	1709	0725	1704	0731	1657	0739	1650	0748	1641	0758	1631	0811	1619
25	0702	1725	0706	1721	0711	1717	0716	1712	0722	1706	0729	1659	0737	1651	0747	1641
Mar.																
2	0650	1736	0653	1733	0656	1729	0700	1726	0705	1721	0710	1716	0716	1710	0724	1703
7	0637	1746	0639	1744	0642	1742	0644	1739	0648	1736	0651	1733	0655	1729	0701	1724
12	0624	1757	0625	1756	0627	1754	0628	1753	0630	1751	0632	1749	0635	1747	0637	1744
17	0611	1807	0611	1807	0612	1807	0612	1806	0612	1806	0613	1806	0614	1805	0614	1805
22	0558	1817	0557	1818	0556	1819	0556	1820	0555	1821	0554	1822	0553	1823	0551	1825
27	0545	1828	0543	1829	0541	1831	0539	1833	0537	1836	0535	1838	0531	1842	0528	1846
Apr.																
1	0531	1838	0529	1840	0526	1843	0523	1847	0519	1850	0515	1855	0510	1900	0504	1906
6	0518	1848	0515	1852	0511	1856	0507	1900	0502	1905	0456	1911	0449	1918	0441	1927
11	0505	1858	0501	1903	0456	1908	0451	1914	0444	1920	0437	1928	0428	1937	0417	1948
16	0453	1908	0447	1914	0441	1920	0434	1927	0426	1935	0417	1945	0406	1957	0352	2011
21	0440	1919	0434	1925	0427	1932	0419	1941	0409	1951	0358	2002	0344	2017	0327	2034
26	0428	1929	0421	1936	0412	1945	0403	1955	0352	2006	0338	2020	0321	2037	0300	2059
May																
1	0417	1939	0408	1947	0359	1957	0348	2009	0334	2022	0318	2039	0259	2059	0232	2126
6	0406	1949	0356	1958	0345	2010	0333	2023	0317	2038	0259	2057	0235	2122	0202	2157
11	0355	1959	0345	2009	0333	2022	0318	2037	0301	2054	0239	2117	0210	2147	0125	2235
16	0346	2008	0334	2020	0321	2034	0304	2050	0245	2111	0219	2137	0143	2215	0026	□□
21	0337	2017	0325	2030	0310	2045	0252	2103	0229	2126	0159	2158	0111	2249	□□	□□
26	0330	2025	0316	2039	0300	2056	0240	2116	0214	2142	0138	2219	0021	□□	□□	□□
31	0323	2033	0309	2048	0251	2105	0229	2127	0201	2157	0117	2242	□□	□□	□□	□□
June																
5	0318	2039	0303	2055	0244	2114	0221	2137	0149	2210	0055	2306	□□	□□	□□	□□
10	0315	2044	0259	2101	0239	2120	0214	2145	0139	2221	0029	2336	□□	□□	□□	□□
15	0313	2048	0256	2105	0236	2125	0210	2151	0133	2229	□□	□□	□□	□□	□□	□□
20	0313	2050	0256	2107	0235	2128	0209	2154	0131	2232	□□	□□	□□	□□	□□	□□
25	0314	2051	0257	2107	0237	2128	0211	2154	0133	2232	□□	□□	□□	□□	□□	□□
30	0317	2050	0301	2106	0241	2126	0215	2151	0139	2227	□□	2353	□□	□□	□□	□□

□□ Sun above horizon. ■■ Sun below horizon.

TABLE II—(concluded)
LOCAL TIME OF SUNRISE AND SUNSET

Lat.	56°		58°		60°		62°		64°		66°		68°		70°	
	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set	Rise	Set
July																
5	0322	2047	0306	2102	0246	2122	0222	2146	0148	2219	0045	2319	□□	□□	□□	□□
10	0327	2042	0312	2057	0254	2115	0231	2138	0201	2208	0111	2256	□□	□□	□□	□□
15	0334	2037	0320	2051	0303	2108	0242	2128	0214	2155	0134	2234	□□	□□	□□	□□
20	0342	2029	0329	2043	0313	2058	0254	2117	0229	2141	0156	2214	0054	2310	□□	□□
25	0350	2021	0338	2033	0324	2048	0306	2105	0245	2126	0216	2153	0133	2234	□□	□□
30	0400	2012	0348	2023	0335	2036	0320	2051	0301	2110	0236	2133	0203	2205	0103	2300
Aug.																
4	0409	2002	0359	2012	0347	2024	0333	2037	0317	2053	0256	2113	0229	2140	0148	2218
9	0419	1951	0409	2000	0359	2010	0347	2022	0332	2036	0315	2054	0252	2115	0221	2145
14	0428	1940	0420	1948	0411	1957	0400	2007	0348	2019	0333	2034	0314	2052	0250	2116
19	0438	1928	0431	1935	0423	1943	0414	1952	0403	2002	0350	2014	0335	2030	0315	2049
24	0448	1916	0442	1921	0435	1928	0427	1936	0418	1945	0407	1955	0355	2007	0339	2023
29	0458	1903	0453	1908	0447	1913	0441	1920	0433	1927	0424	1935	0414	1946	0401	1958
Sept.																
3	0508	1850	0503	1854	0459	1858	0454	1903	0448	1909	0441	1916	0432	1924	0422	1934
8	0517	1837	0514	1840	0511	1843	0507	1847	0502	1852	0457	1857	0451	1903	0443	1910
13	0527	1824	0525	1826	0522	1828	0520	1831	0516	1834	0513	1837	0508	1841	0503	1846
18	0537	1810	0536	1812	0534	1813	0532	1814	0531	1816	0529	1818	0526	1820	0523	1823
23	0547	1757	0546	1757	0546	1758	0545	1758	0545	1758	0544	1759	0544	1759	0543	1800
28	0556	1744	0557	1743	0558	1742	0558	1742	0559	1741	0600	1740	0601	1738	0602	1737
Oct.																
3	0606	1731	0608	1729	0610	1727	0611	1725	0614	1723	0616	1721	0619	1717	0622	1714
8	0616	1718	0619	1715	0622	1712	0625	1709	0628	1706	0632	1701	0637	1657	0643	1651
13	0627	1705	0630	1702	0634	1658	0638	1653	0643	1648	0649	1643	0655	1636	0703	1627
18	0637	1653	0641	1648	0646	1643	0652	1638	0658	1631	0705	1624	0714	1615	0725	1604
23	0647	1640	0653	1635	0659	1629	0705	1622	0713	1614	0722	1605	0733	1554	0747	1541
28	0658	1629	0704	1623	0711	1615	0719	1607	0729	1558	0740	1547	0753	1533	0810	1516
Nov.																
2	0709	1618	0716	1610	0724	1602	0734	1553	0745	1541	0758	1528	0814	1512	0835	1451
7	0719	1607	0728	1559	0737	1550	0748	1539	0801	1526	0816	1510	0836	1451	0901	1426
12	0730	1558	0739	1549	0750	1538	0802	1525	0817	1511	0835	1452	0858	1429	0929	1358
17	0740	1549	0751	1539	0803	1527	0816	1513	0833	1456	0854	1435	0921	1408	1002	1327
22	0750	1542	0802	1530	0815	1517	0830	1502	0849	1443	0913	1419	0946	1345	1043	1248
27	0800	1535	0812	1523	0826	1509	0843	1452	0904	1431	0932	1403	1012	1322	■■	■■
Dec.																
2	0808	1530	0821	1517	0837	1502	0855	1443	0918	1420	0950	1349	1041	1257	■■	■■
7	0816	1527	0830	1513	0846	1457	0906	1437	0931	1412	1006	1336	1118	1225	■■	■■
12	0822	1525	0836	1511	0854	1454	0914	1433	0941	1406	1020	1327	■■	■■	■■	■■
17	0827	1525	0842	1511	0859	1453	0921	1432	0949	1403	1030	1322	■■	■■	■■	■■
22	0829	1526	0844	1511	0902	1454	0923	1432	0952	1404	1035	1321	■■	■■	■■	■■
27	0832	1531	0846	1516	0904	1459	0925	1437	0953	1409	1035	1328	■■	■■	■■	■■
31	0832	1535	0846	1520	0903	1503	0924	1442	0951	1415	1030	1336	■■	■■	■■	■■

□□ Sun above horizon. ■■ Sun below horizon.

TABLE III
FACTORS FOR THE YEAR
(To be used only with Table IV)

Year	Factor	Year	Factor	Year	Factor	Year	Factor	Year	Factor
1901	−0.51	1921	−0.35	1941	−0.20	1961	−0.04	1981	+0.12
1902	−0.75	1922	−0.59	1942	−0.44	1962	−0.28	1982	−0.12
1903	−0.99	1923	−0.84	1943	−0.68	1963	−0.52	1983	−0.37
1904*	−1.23	1924*	−1.08	1944*	−0.92	1964*	−0.76	1984*	−0.61
1904	−0.23	1924	−0.08	1944	+0.08	1964	+0.24	1984	+0.39
1905	−0.48	1925	−0.32	1945	−0.16	1965	−0.01	1985	+0.15
1906	−0.72	1926	−0.56	1946	−0.41	1966	−0.25	1986	−0.09
1907	−0.96	1927	−0.80	1947	−0.65	1967	−0.49	1987	−0.34
1908*	−1.20	1928*	−1.05	1948*	−0.89	1968*	−0.73	1988*	−0.58
1908	−0.20	1928	−0.05	1948	+0.11	1968	+0.27	1988	+0.42
1909	−0.44	1929	−0.29	1949	−0.13	1969	+0.02	1989	+0.18
1910	−0.69	1930	−0.53	1950	−0.37	1970	−0.22	1990	−0.06
1911	−0.93	1931	−0.77	1951	−0.62	1971	−0.46	1991	−0.30
1912*	−1.17	1932*	−1.02	1952*	− 0.86	1972*	−0.70	1992*	−0.55
1912	−0.17	1932	−0.02	1952	+0.14	1972	+0.30	1992	+0.45
1913	−0.41	1933	−0.26	1953	−0.10	1973	+0.06	1993	+0.21
1914	−0.66	1934	−0.50	1954	−0.34	1974	−0.19	1994	−0.03
1915	−0.90	1935	−0.74	1955	−0.58	1975	−0.43	1995	−0.27
1916*	−1.14	1936*	−0.98	1956*	−0.83	1976*	−0.67	1996*	−0.52
1916	−0.14	1936	+0.02	1956	+0.17	1976	+0.33	1996	+0.48
1917	−0.38	1937	−0.23	1957	−0.07	1977	+0.09	1997	+0.24
1918	−0.62	1938	−0.47	1958	−0.31	1978	−0.16	1998	0.00
1919	−0.87	1939	−0.71	1959	−0.55	1979	−0.40	1999	−0.24
1920*	−1.11	1940*	−0.95	1960*	−0.80	1980*	−0.64	2000*	−0.48
1920	−0.11	1940	+0.05	1960	+0.20	1980	+0.36	2000	+0.52

*Use these values for January and February. Do not interpolate Table III.

Dusk, Dawn and Twilight

Dawn is usually defined as the time when daylight first appears in the morning sky. Morning twilight is the interval of time between dawn and sunrise. Evening twilight is the interval between sunset and dusk; dusk being defined as the last appearance of daylight in the evening sky.

The illumination of the sky during twilight is due to the rays of the sun which strike the upper layers of the earth's atmosphere; the duration of twilight is hence due to the rate at which the sun sinks below the horizon.

Three intervals of twilight are recognized. Civil twilight is the interval between sunrise or sunset and the times when the centre of the sun is 6° below the horizon. It is that interval during which ordinary outdoor operations are possible with natural illumination, and beyond which

TABLE IV
FACTORS FOR LONGITUDE
(To be used only with Table III)

West Long.	Factor	West Long.	Factor	East Long.	Factor	East Long.	Factor
°		°		°		°	
5	+0.01	105	+0.29	5	−0.01	105	−0.29
10	+0.03	110	+0.31	10	−0.03	110	−0.31
15	+0.04	115	+0.32	15	−0.04	115	−0.32
20	+0.06	120	+0.33	20	−0.06	120	−0.33
25	+0.07	125	+0.35	25	−0.07	125	−0.35
30	+0.08	130	+0.36	30	−0.08	130	−0.36
35	+0.10	135	+0.38	35	−0.10	135	−0.38
40	+0.11	140	+0.39	40	−0.11	140	−0.39
45	+0.12	145	+0.40	45	−0.12	145	−0.40
50	+0.14	150	+0.42	50	−0.14	150	−0.42
55	+0.15	155	+0.43	55	−0.15	155	−0.43
60	+0.17	160	+0.44	60	−0.17	160	−0.44
65	+0.18	165	+0.46	65	−0.18	165	−0.46
70	+0.19	170	+0.47	70	−0.19	170	−0.47
75	+0.21	175	+0.49	75	−0.21	175	−0.49
80	+0.22			80	−0.22		
85	+0.24			85	−0.24		
90	+0.25			90	−0.25		
95	+0.26			95	−0.26		
100	+0.28			100	−0.28		

In Table IV, it is sufficient to use the factor for the nearest 5° of longitude.

artificial light may be required. The brightest stars are still visible at the beginning of morning civil twilight and have made their appearance by the end of evening civil twilight. The amount of illumination available on a particular day during civil twilight is largely dependent on the local topography and the weather.

Nautical twilight is the interval between sunrise or sunset and the time that the centre of the sun is 12° below the horizon.

Astronomical twilight is the interval between sunrise or sunset and the time that the centre of the sun is 18° below the horizon.

Table V gives the durations of Civil, Nautical and Astronomical twilights, as defined above, as well as the duration of daylight for the first of each month at the two latitudes 45° and 50°.

Total Hours of Daylight

Table VI gives the total hours of daylight between sunrise and sunset for locations between 42° and 64°4 north latitudes. The intervals are for

TABLE V
DURATION OF TWILIGHT AND DAYLIGHT

Date	Latitude 45°				Latitude 50°			
	Twilight			Daylight	Twilight			Daylight
	Civil	Nautical	Astronomical		Civil	Nautical	Astronomical	
	h m	h m	h m	h m	h m	h m	h m	h m
Jan. 1	0 34	1 11	1 46	08 51	0 38	1 20	1 59	08 10
Feb. 1	0 31	1 07	1 41	09 48	0 35	1 14	1 52	09 20
Mar. 1	0 30	1 04	1 38	11 08	0 33	1 10	1 48	10 58
Apr. 1	0 30	1 05	1 42	12 46	0 33	1 12	1 54	12 55
May 1	0 33	1 13	1 58	14 15	0 37	1 24	2 20	14 41
June 1	0 36	1 24	2 24	15 22	0 43	1 44	—	16 04
July 1	0 37	1 26	2 31	15 33	0 44	1 48	—	16 18
Aug. 1	0 34	1 16	2 05	14 42	0 39	1 29	2 35	15 14
Sept. 1	0 30	1 07	1 45	13 16	0 34	1 15	1 59	13 31
Oct. 1	0 29	1 03	1 38	11 43	0 32	1 10	1 48	11 39
Nov. 1	0 31	1 05	1 39	10 11	0 34	1 12	1 50	09 48
Dec. 1	0 33	1 10	1 45	09 02	0 37	1 18	1 57	08 24

— Sun does not reach 18° below the horizon.

leap year, which means an additional day at the end of February. It adds less than 12 hours to the monthly and annual totals of daylight which would occur in an ordinary year. In the event of clear skies and unobstructed horizon, Table VI also indicates the maximum hours of sunlight possible.

TABLE VI
TOTAL HOURS (LEAP YEAR) BETWEEN SUNRISE AND SUNSET AT VARIOUS LATITUDES, NORTHERN HEMISPHERE

Latitude / Month	42°	44°	46°	48°	50°	52°	54°	56°	58°	60°	64°4
January	295	289	282	275	267	258	248	237	225	210	168
February	307	304	301	297	292	287	283	277	271	264	248
March	371	371	371	370	369	368	368	367	367	366	367
April	402	405	408	411	413	417	422	426	431	438	457
May	452	458	465	471	478	486	496	506	518	532	578
June	456	463	471	479	489	499	511	525	542	560	633
July	461	468	475	483	492	502	513	525	540	557	610
August	428	432	436	441	447	453	459	467	474	483	506
September	374	374	375	376	379	380	381	383	385	387	389
October	342	340	338	335	333	330	327	323	319	314	299
November	294	289	284	278	272	265	257	249	238	227	191
December	285	276	270	262	253	243	232	219	204	187	131
Year Total	4467	4469	4476	4478	4484	4488	4497	4504	4514	4525	4577

Provincial Legislation

One can still find, in some cities, two, and occasionally three, different times. If, by law, a registry office must open at nine a.m., then the law must define what time is to be used by offices or institutions under its control. The official legislation in Canada in regard to time chiefly affects such matters as the times of coming into effect or expiration of acts, ordinances, contracts and agreements, times of opening and closing registration offices, law courts, post offices and similar public offices, times of open or close seasons for game, times of opening and closing business houses and places of amusement.

In general, laws relating to the definition of time provide that where an expression of time occurs in any act of the legislature or in any Rule of Court, in any by-law, deed or other legal instrument, or where any hour or other period of time is stated, either orally or in writing, or where any question as to a period of time arises, the time referred to or intended shall, unless it be otherwise specifically stated, be held to be . . . standard time.

Where railway or other transportation companies are under the jurisdiction of any province, laws regulating the times appearing on their schedules have been passed by some of the provinces.

It is seen that several provinces have enacted laws relating to the adoption of daylight saving. Where no provincial law has been passed, different cities and towns have frequently adopted daylight saving by by-law under their general powers of legislation.

The provinces have wisely refrained from enacting restricting laws on matters of time except where the value was quite evident, and a household, church, lodge, or community clock may be set as fast or as slow as the owners desire. The Dominion Government has limited its legislation to the Act of 1918, which has been interpreted as lapsing at the end of that year, and to the Orders-in-Council during World War II which were revoked in 1945. Hence there is, in Canada, no law governing matters of time in reference to interprovincial carriers and similar matters, and no body exercising powers in relation to time similar to those of the Interstate Commerce Commission in the United States.

The following legislation governs the standard times to be used in the several provinces and territories. Laws regulating such times as those of opening and closing of public buildings, close seasons, rules of the road, etc., have not been included.

Yukon. Interpretation Ordinance, 1955, Chap. 16.

(1) "Subject to this section, standard time shall be reckoned as nine hours behind Greenwich Time and called Yukon Standard Time."

(2) "Notwithstanding subsection (1), the Commissioner may make regulations varying the manner of reckoning standard time."

British Columbia. Sec. 48, Interpretation Act.

"Time to be held to be what is known as Pacific Standard Time and subject to the provisions of the Daylight Saving Act . . . should be reckoned as eight hours behind Greenwich time."

Northwest Territories. Interpretation Ordinance, Chap. 52, 1956.

(1) "In that part of the Territories lying to the east of the sixty-eighth meridian of west longitude the standard time shall be the local time of the sixtieth meridian and called Atlantic Standard Time."

(2) "In that part of the Territories included between the sixty-eight meridian and the eighty-fifth meridian of west longitude, and including also Southampton Island and the islands adjacent to Southampton Island, the standard time shall be the local time of the seventy-fifth meridian of west longitude and called Eastern Standard Time."

(2) "In that part of the Territories included between the sixty-eighth meridian and the one hundred and second meridian of west longitude but excepting Southampton Island and the islands adjacent to Southampton Island, the standard time shall be the local time of the ninetieth meridian of west longitude and called Central Standard Time."

(4) "In that part of the Territories included between the one hundred and second meridian and one hundred and twentieth meridian of west longitude the standard time shall be the local time of the one hundred and fifth meridian and called Mountain Standard Time, and

(5) "In that part of the Territories lying to the west of the one hundred and twentieth meridian of west longitude the standard time shall be the local time of the one hundred and twentieth meridian and called Pacific Standard Time."

Alberta. The Interpretation Act, Section 26 (chap. 160 of The Revised Statutes of Alberta, 1955).

(1) "A reference to time shall be deemed a reference to that time known as Mountain Standard Time, and being seven hours behind Greenwich Time."

(2) "Notwithstanding subsection (1), for any period during which Daylight Saving Time must be observed pursuant to an order of the Governor-General-in-Council made under the authority of the War Measures Act (Canada), a reference in any Act or regulation to any particular time of day shall be deemed a reference to that time known as Mountain Daylight Saving Time and being one hour in advance of Mountain Standard Time, and where the expression "Mountain Standard Time" appears in any Act or regulation such expression shall be read as "Mountain Daylight Saving Time."

Saskatchewan. The Interpretation Act, 1920.

"The time known as Mountain Standard Time (being the local time at the one hundred and fifth meridian of west longitude . . .) is hereby declared to be standard time of the province." By the Court Officials Act, City Act, and Town Act, Central Standard Time is given legal sanction in certain municipalities in the southeastern part of the province." (Legislation is pending which would put the entire province on Central Standard Time in the summer months, and on Mountain Standard Time during the winter months, the changes to occur the last Sunday in April and the last Sunday in September.)

Manitoba. The Interpretation Act, Chapter 33, Annual Statutes, 1957.

(1) "A reference to time is to be deemed a reference to Central Standard Time, which is the mean time of the ninetieth degree of longitude west from Greenwich, and is six hours behind Greenwich Mean Time."

(2) "A reference to Daylight Saving Time is to be deemed a reference to a time one hour in advance of Central Standard Time."

(3) "Where, in the opinion of the Lieutenant-Governor-in-Council, Daylight Saving Time has been adopted for general use in any municipality or local government district, the Lieutenant-Governor-in-Council may by Order-in-Council direct that the hours and times to be observed shall be Daylight Saving Time during any period for which Daylight Saving Time has been adopted in the Municipality."

Ontario. Revised Statutes, 1950, Chap. 90.

(a) "As regards that part of Ontario which lies east of the meridian of ninety degrees west longitude" time shall be reckoned "as five hours behind Greenwich Time."

(b) "As regards that part of Ontario which lies west of that meridian" . . . time shall be reckoned "as six hours behind Greenwich." Providing also that the Lieutenant-Governor-in-Council may from time to time make regulations varying the reckoning of standard time as above defined. Such regulations may authorize the Ontario Railway and Municipal Board to fix the time tables of all railways subject to its control. . . ."

Quebec. Standard Time Act, 1941, Chap. 2

(2) "In that part of the Province which lies east of the meridian of sixty-eight degrees west longitude, Standard Time shall be reckoned as four hours behind Greenwich Time. In that part of the Province which lies west of that meridian, Standard Time shall be reckoned as five hours behind Greenwich Time."

(3) "The Lieutenant-Governor-in-Council may . . . amend or replace regulations to change the standard time as defined in Section (2)."

(4) "Such regulations may authorize the Quebec Public Service Commission to fix the time-tables of any public service under its control."

Daylight Saving Act, 1941, provides for the establishing of daylight saving by Order-in-Council when a municipality has requested it.

New Brunswick. Chapter 47 of 9 George VI, (1945), An Act to Adopt Atlantic Standard Time.

"Provides for Atlantic Standard Time and reckons it as being four hours behind Greenwich Time."

Nova Scotia. Time Definition Act, Chap. 290, Revised Statutes, 1954.

(1) "Where an expression of time occurs in any statute . . . time shall be reckoned as four hours behind Greenwich Mean Solar Time."

(2) "The Governor-in-Council may in each year by proclamation published in the Royal Gazette prescribe that as regards any period in such year between the thirty-first day of March and the first day of November, such period to be specified in the proclamation, time shall be reckoned as three hours behind Greenwich Mean Solar Time."

Prince Edward Island. The Time Uniformity Act R.S.P.E.I., 1951, Chapter 161.

1. "There shall be one standard uniform official time in use throughout Prince Edward Island. 1947, c. 39, s.2."

2. "Unless altered by Order-in-Council as hereafter provided, such official time shall be the Standard Time as established by section 20(m) of The Interpretation Act, 1947, c. 39, s.3." (Atlantic Standard Time).

3. "The Lieutenant-Governor-in-Council may by Order-in-Council institute the observance of Daylight Saving Time (so-called) being one hour in advance of Standard Time, for such period of time during each year as may be deemed advisable, and when so instituted, such time shall be deemed the official time during the period so specified. 1947, c.39, s.4."

Newfoundland. The Standard Time (Newfoundland) Act, 1935. Amended 1949.

1. "Where any expression relating to time reckoned or to be reckoned in Newfoundland or its Dependencies occurs in any statute, . . . During the period in each year between midnight on the last Sunday in April and midnight on the last Sunday in September, the hour of noon shall be fixed as two and one-half hours later and during the remainder of the year as three and one-half hours later than noon by mean solar time at Greenwich and all other hours shall be reckoned accordingly."

3. The Act 8 & 9 George V, Chapter 1, entitled "An Act respecting certain changes in the Hours of the Day and Night" is hereby repealed.

Dominion Legislation

It is one thing to decree that such a thing shall be done at 6 o'clock eastern standard time, but quite another to decide just when 6 o'clock occurs. By Order-in-Council P.C. 6784, August 28, 1941, the Dominion Observatory time was declared the time to be used for official purposes in Canada. For many years prior to this the Observatory had served unofficially as a source of accurate time for a variety of purposes. Observatory time is made available continuously to the Canadian Broadcasting Corporation, and is broadcast daily by a network of stations for about half a minute at 1:00 p.m. eastern time. It is also made available to the two telegraph companies and to the Bell Telephone Company. A 24-hour service is provided, together with a voice announcement each minute, via CHU, which operates on frequencies of 3330 kc., 7335 kc. and 14670 kc.

AN INSTRUMENT FOR CALCULATING PRECESSION*

By D. H. Andrews

Dominion Astrophysical Observatory, Victoria, B.C.

Abstract

A device for determining precessions for any number of years up to one hundred is described in theory, construction and operation. The precession calculator works to an accuracy of approximately $\pm 0^{s}.05$ in right ascension and about $\pm 0'.2$ in declination within its operating limits of 0^{h} to 24^{h} in right ascension and $-30°$ to $+80°$ in declination.

In setting telescopes, especially the larger instruments, it is desirable to employ the current co-ordinates of the object. This entails precessing catalogued positions, either by use of annual precessions given in some catalogues or, with the concomitant mental interpolations, by the aid of such invaluable precession tables as are published in the *Observer's Handbook* of this Society. Unfortunately, this procedure often has to be carried out when the observer's arithmetical faculties are not at their keenest; consequently, both observing time and composures are sometimes lost. Therefore, a device whose operation is speedy and one of solely mechanical routine should alleviate the problem to some extent. The precession calculator described in this paper approaches these requirements with an additional advantage. When observing programmes requiring several years of observation are being prepared, once the initial precessions are determined, precessional corrections or, usually, the final co-ordinates for any number of years may be tabulated immediately at the mere cost of the time required to write them down.

Theory. The annual precessions, p_α and p_δ, in right ascension, α, and declination, δ, are given (Smart, 1931) by the equations:

$$p_\alpha = m + n \sin\alpha \tan\delta \tag{1}$$

$$p_\delta = n \cos\alpha. \tag{2}$$

Since n and m involve the annual general precession and the obliquity, they may be considered to be constants for our purposes. Their annual variations are approximately 6×10^{-6} and 2×10^{-5} seconds of time per year, respectively.

Contributions from the Dominion Astrophysical Observatory, No. 62. Published by permission of the Deputy Minister, Department of Mines and Technical Surveys, Ottawa, Canada.

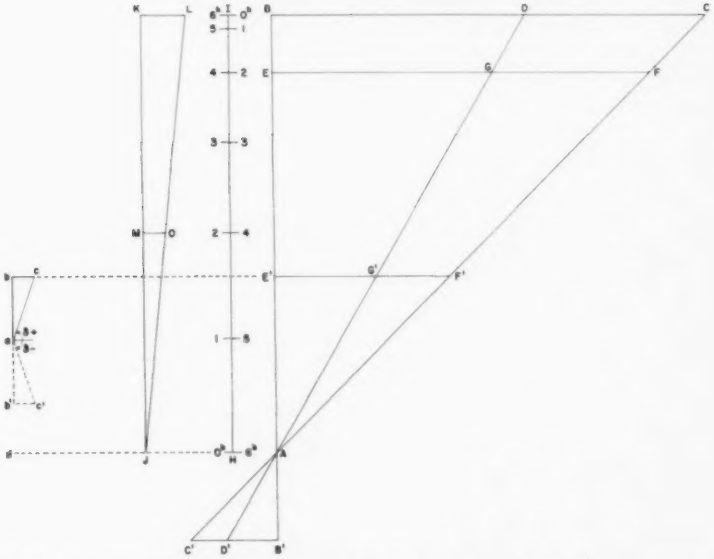


FIG. 1—A nomograph which may be adapted for the mechanical determination of precessions.

A simple nomograph, amenable to mechanical application, for calculating the precession in declination, Np_δ, for N years is shown in figure 1. Consider the right-angled triangle ABC and let BC be divided into 100 equal units, each representing one year. The line AD is drawn such that $BD = N$ units or years. The triangle ABC is isosceles and thus for any line EF parallel to BC, $AE = EF$. Now, if AE represents the precession in declination for 100 years for the right ascension in question, i.e., $AE = 100\ p_\delta$, then $EF = 100\ p_\delta$. Furthermore, by an elementary theorem of geometry, $EG = (N/100)EF = Np_\delta$. From equation (2) we see that we must set $AE = 100\ n \cos\alpha$. This is accomplished by having the scale HI graduated directly as $\cos\alpha$ as shown to its right for the first quadrant. The factor $100n$ is of course taken care of by the scale used to read off EG. Giving the precession the appropriate sign, as ascertained by the sign of $\cos\alpha$, completes the determination of Np_δ.

It is convenient to use the same triangle ABC, plus the right-angled triangle $AB'C'$ to accommodate negative precessions, to calculate Np_α, the precession in right ascension for N years.

In order to utilize the same line AD as before to reduce $100p_\alpha$ to Np_α, AE' must now be given by: $AE' = 100p_\alpha$, measured in units of

p_α. From equation (1) we have: $100p_\alpha = 100m+100n \sin\alpha \tan\delta$. The small right-angled triangle abc allows us to determine $100n \sin\alpha \tan\delta$. If $bc = 100n \sin\alpha$ in units of p_α and angle $acb = \delta$, then $ab = 100n \sin\alpha \tan\delta$. Furthermore, if a is fixed such that $da = 100m$ in units of p_α, then $db = 100m+100n \sin\alpha \tan\delta = AE'$ as we require.

In order to determine bc we use the same scale, HI, but numbered as shown at its left. For clarity, only first quadrant graduations are shown. This gives us $JM = 100n \sin\alpha$ but in units of p_δ. To convert to units of p_α we draw the line JL so that $KL = 100n$ in units of p_α. Then $MO = 100n \sin\alpha$ in units of p_α. Having the slopes of JL at our disposal allows us to choose a scale of convenient ruling to read off Np_α. In practice, the length of MO is transferred mechanically to bc.

If δ is negative, we draw the triangle $ab'c'$ such that angle $ac'b = \delta$. This procedure also permits us to allow for the negative sign of $\sin\alpha$ when $12^h < \alpha < 24^h$ simply by setting $\delta = -\delta$ in this region. If $n \sin\alpha \tan\delta$ is negative and greater than $m = ad$, Np_α will be negative and will be read by using the line AD'.

The theoretical accuracy of the above determinations is limited by the secular variation of p_α and p_δ. For practical purposes of telescope setting, the secular variation terms may be neglected in the range $|\delta| < 80°$ for which the precession calculator was designed.

Construction and Operation. The construction and operation of the precession calculator, shown in figure 2, follows very closely the procedures outlined in the preceding section. Because of the inevitable loss of detail in reproducing a photograph of an object that was difficult to photograph satisfactorily, the parts have been labeled for ease of description to correspond to figure 1.

The device is constructed mainly of $\frac{3}{16}''$ plastic and has an overall size of approximately $4'' \times 21'' \times 23''$. Illumination is provided by a shaded 16″ lumeline lamp at the top. All scales were ruled by hand using an accurate drafting scale. Numbering and lettering were inscribed using a sharp stylus in a Leroy-type draftsmen's lettering guide. The adjustments after construction were readily accomplished using known precessions.

The upper surface of the plastic bounded by ABC and $AB'C'$ has been ground for ease of drawing and erasing the line $D'D$. The undersurface of this area has been enameled white to make this line and the read-out scales readily visible. For convenience of ruling, the scale along BC is ten inches long and is graduated for each year from 0 to 100 years.

The right ascension setting scale, HI, has its numbering arranged in columns to distinguish the two settings of the same right ascension that

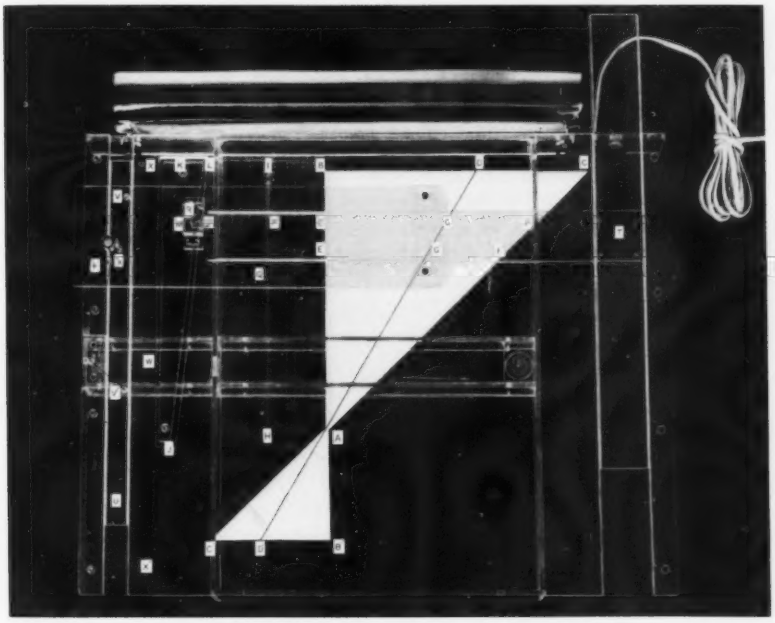


FIG. 2—Detailed plan view of the precession calculator.

must be made to determine Np_δ and Np_α. These columns also indicate the sign that must be given to Np_δ and for what region of right ascension one must set $\delta = -\delta$ in obtaining Np_α.

The read-out scales for Np_δ and Np_α, along EF and $E'F'$ respectively, are ruled on the leg of a sliding "T" section. The cursor, P, for making right ascension settings is colinear with EF. The one minute of arc units of Np_δ turn out to be approximately 0.3 inches in length. For convenience, the Np_α scale is inscribed with 0.1-inch graduations representing 0^m2 of precession in right ascension. This latter scale reads positively to the right of E' and negatively to the left.

The leg of the "T" also has the sliding unit Q on its left end. This is used to determine MO and eventually to transfer this distance to bc. The line JL of figure 2 is replaced by an adjustable, recessed straight edge which acts as a stop for the plunger R. When Q is in position so that the plunger, when depressed, will just touch this straight edge, the centre of a cross below the lens S will be displaced to the right of ab

(extended) by an amount equal to MO. The centre of the cross is co-linear with $E'F'$.

The sides ac or ac' of the triangles abc or $ab'c'$ are formed by black nylon thread under tension. The thread path, most of which is under the top, and the elastic insert are shown schematically in figure 3. The very small hole through which the thread passes at a is shaped in order to reduce thread wear as shown in figure 3. The extremities of the thread are fastened to a sliding member U at V and V'. The angle bca is formed by setting the index at V to δ on the tan δ scale, WX. If δ is negative, V' is set to δ on the tan δ scale, WX'.

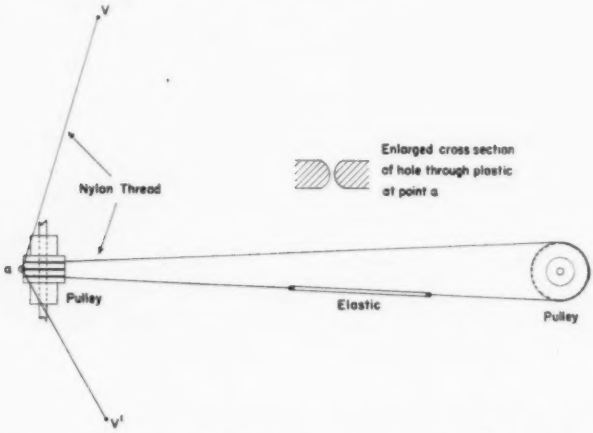


FIG. 3—Schematic plan view of the device for constructing the declination angle.

To read off Np_δ it remains only to slide the "T" section up or down until the centre of the cross at S bisects the thread at c, or c' if δ is negative.

The device is particularly useful for preparing observing programmes that require a number of years for their completion. For such use the operator draws several lines, $D'D$, separated by two-year intervals say; for example, 58, 60, and 62 to precess 1900 co-ordinates for use over the next five years. He then slides the "T" section until the cursor P reads the right ascension of the star, using the figures in the appropriate declination columns, and reads the precessional corrections in declination directly from the intersections at G of the various lines $D'D$ with EF. To obtain the precession in right ascension the operator now resets the cursor P to read the star's right ascension as given in the right ascension

columns. With the plunger depressed, he slides Q until the plunger stops against the straight edge. After releasing the plunger, the declination index V, or V', is set and the "T" section is moved so that the cross at S bisects the appropriate thread. The precessions are then read off at the intersections at G' of the year lines with $E'F'$.

With careful settings, the accuracy of Np_δ is approximately $\pm 0'.2$ and of Np_α, about $\pm 0^m.05$. This is sufficiently precise for setting most large telescopes engaged in normal spectrographic work.

It is difficult and, indeed, unwarranted to make an accurate comparison of the times required to obtain precessions using 50-year tables and by means of the precession calculator. The results would depend too heavily upon the particular ability of the person using the tables and any such comparisons are thus left to the reader. Determining and recording the precessions to the nearest minute of arc in declination and the nearest tenth of a minute of time in right ascension requires about 40 seconds using the precession calculator. However, it requires at most only five seconds more to record the corrections for three alternate years and since it is possible to interpolate at sight for the intervening years, the average time required to obtain a given year's precessional corrections is approximately nine seconds. To these times one must, of course, add the time required to apply the corrections and record the final co-ordinates.

Perhaps more important than any saving in time is the ease and comparative freedom from error with which this device operates as has been evidenced by its successful use over a period of several months.

In conclusion I wish to express my appreciation to Mr. S. H. Draper for his work in preparing the diagrams and photographs.

References

Smart, W. M. 1931, *Spherical Astronomy*, Cambridge University Press, p. 239.

METEOR NEWS

By Peter M. Millman

National Research Council, Ottawa

The Heights of Meteors

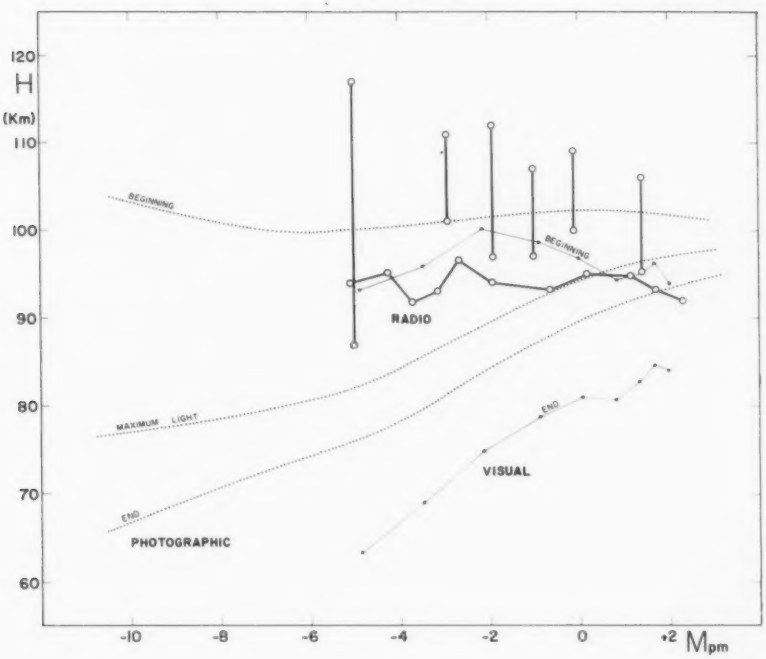
Just recently Dr. D. W. R. McKinley and myself have been summarizing various properties of meteors. In particular we have been studying the relations between results obtained by various observational techniques. The full account of these studies will appear elsewhere but a brief summary of some information on meteor heights may be of interest at this time to readers of the Journal.

Figure 1 shows the relation between meteor heights and the photographic absolute magnitude of the meteor at maximum light, as determined from a number of systematic programmes of observation. Absolute magnitude is defined as the magnitude of any meteor when it is observed in the zenith at a height of 100 km.

The visual records in the figure are taken from Table XXV of Öpik's discussion (1) of the results of the Harvard Arizona Meteor Expedition, 1931–32. The visual magnitudes have been converted to photographic magnitudes by a modified form of the colour index function determined by Jacchia (2). The values plotted are smoothed by taking running means and these represent a total of 2,830 meteors visually observed on the Arizona Expedition. Only the values for the beginning and end of the meteor trails have been plotted.

The photographic results are means from three Harvard photographic programmes. The data consist of 217 meteors photographed with small cameras in Cambridge, Mass., and near Las Cruces, New Mexico. These have been studied by F. L. Whipple and L. G. Jacchia (3). In addition to this we have heights for 263 long trail meteors, photographed with the Super-Schmidt meteor cameras in New Mexico, (L. G. Jacchia—private communication,) and 358 Super-Schmidt meteors randomly selected and reduced by G. S. Hawkins and R. B. Southworth (private communication). Sincere thanks go to the four astronomers mentioned above for supplying some of their observational data in advance of publication.

In the photographic data no conversion for magnitude was necessary.



The heights for each meteor were, however, individually corrected for the systematic effect of velocity and reduced to values corresponding to a standard geocentric velocity of 45 km./sec. The corrections, determined from data themselves, are listed in Table I.

The radio heights, represented by solid heavy lines in the diagram, summarize the unpublished measures by Millman and McKinley, using a three-station radar network (4). The almost horizontal line is the average for 645 meteors, taking the long enduring portion of the radar echo. These heights have all been corrected to a standard at a velocity of 45 km./sec. The vertical lines are means for the beginning and end heights of 76 very short duration "h" and "B" type echoes, sometimes called the "head echo".

It will be noted that there is a general tendency for meteors to become visible at approximately the same height, regardless of their intrinsic luminosity. The end heights, however, are considerably lower for the brighter (and more massive) objects. The visual heights seem system-

TABLE I

CORRECTION TO REDUCE HEIGHTS OF METEORS TO A STANDARD CORRESPONDING TO 45 KM./SEC.

Observed Meteor Velocity	Correction to Height
(km./sec.)	(km.)
10–15	+19
15–20	+13
20–25	+ 8
25–30	+ 6
30–35	+ 5
35–40	+ 3
40–45	+ 1
45–50	− 1
50–55	− 3
55–60	− 5
60–65	− 6
65–70	− 8
70–75	−10

atically too low, suggesting some systematic error either in the method of observation or in the reductions. Greater reliance should be placed on the instrumental results.

REFERENCES

(1) Öpik, E., *Annals of the Harvard Observatory*, Vol. 105, p. 549, 1937.
(2) Jacchia, L. G., *Astron. Journal*, Vol. 62, p. 358, 1957.
(3) Jacchia, L. G., Harvard Obs. and Analysis Lab., M. I. T., Technical Report No. 10, 1952.
(4) Millman, P. M., and McKinley, D. W. R., *Sky and Telescope*, Vol. 8, p. 114, 1949.

NOTES FROM OBSERVATORIES

DOMINION ASTROPHYSICAL OBSERVATORY, VICTORIA, B.C.

On April 1, 1958 J. A. Pearce began his retirement leave, after nearly 34 years of continuous service to the Observatory. Despite his well-merited retirement, he is continuing with his spectroscopic studies. Dr. Pearce has contributed very greatly to our knowledge of the radial velocities of the stars, and has distinguished himself particularly by his numerous researches on spectroscopic double stars. At a party in his honour held at the Observatory, he was presented with a silver cigar box, on the top of which was inscribed the radial-velocity curves of AO Cassiopeiae (Pearce's star).

Seasonal appointments to the staff include J. L. Climenhaga, G. E. Cross, R. L. Hemmings, S. C. Morris, B. R. Parker, and A. J. Perry-Whittingham.

D. H. Andrews has designed and, with the help of J. R. White, built a machine for performing the laborious computations for "reduction to the sun" of radial-velocity measurements. P. E. Argyle, with S. H. Draper and J. R. White, built a special camera for photographing artificial satellites, which has been used successfully on satellite 1958δ.

Several members of the staff have attended scientific meetings: R. M. Petrie, A. B. Underhill and P. E. Argyle, the Vancouver meetings of the Canadian Association of Physicists on March 8; A. McKellar, the Los Angeles meetings of the Astronomical Society of the Pacific on June 10; K. O. Wright, the Madison meetings of the American Astronomical Society on June 29. R. M. Petrie, G. J. Odgers and P. E. Argyle will attend the International Astronomical Union meetings in Moscow in August.

Visitors to the Observatory include W. van Steenburgh, the Director General of Scientific Services and K. M. Pack, Chief Administrative Officer of the Department of Mines and Technical Surveys at Ottawa; J. H. Hodgson, P. L. Willmore, K. Whitham, and G. Madill of the Ottawa Observatory, and J. Housiaux of Liege.

VARIABLE STAR NOTES

By Margaret W. Mayall

The American Association of Variable Star Observers, Cambridge, Mass.

The celebration of the 50th Anniversary of the founding of the Nantucket Maria Mitchell Observatory was one of the highlights of the A.A.V.S.O. Spring meeting held on Nantucket Island from June 12 to 15, 1958. Dr. Dorrit Hoffleit, Director of the Maria Mitchell Observatory, and Miss Margaret Harwood, the former Director, have been enthusiastic members of the A.A.V.S.O. for many years, and both did everything possible to make our visit a memorable one. Nantucket is called the "Far-Away Island"—it lies 30 miles off the Massachusetts coast—and many members took advantage of this meeting to make their first visits to the island. We had a total of 96 people at the Association dinner, which may have set an all time record for attendance. Our members came from the North (the Goods, the Morgans and Miss Drolet from Montreal), the South (M. V. Barnhill, Wilmington, North Carolina), and the West (Mrs. Marjorie Leavens, Colorado Springs), and many points in between.

The two feature lectures of the meeting were given, (1) by Dr. Edward Lilley of Yale University Observatory on "Rockets, Radio and Astronomy"; and (2) by Miss Margaret Harwood on "The First 50 Years of the Maria Mitchell Observatory." Others papers presented included the following: "Cepheid Variables and the Revised Distance Scale", Francis P. Morgan; "Nova Sagittarii 1932", Jean Anderson; "Astronomy on Postage Stamps," Kenneth S. Baird; "Miscellaneous Variable Star Notes," Margaret W. Mayall; "Unusual Aspects of the Current Solar Cycle", Harry L. Bondy; "Magnitude Variations of 2 Sputniks," Philip Seldon; "Solar Tetragons," James C. Bartlett, Jr.; "The Bright RV Tauri Variables," Edward G. Oravec; "The Stars are my Photometer," Norman B. Godfrey; "The Fernwold Observatory," Cyrus F. Fernald; "Naked Eye Observations of Algol," Frances E. Ruley; "Around the World with Mlle. Dedee Lacertae," John J. Ruiz; "Moon Occultations," Luiz Muniz-Barreto; "The Observatory on Kitt Peak," Charles A. Federer, Jr.; and "A Curious Light Phenomenon Seen from an Airplane," Kenneth Weitzenhoffer: More details on the papers will be given in the A.A.V.S.O. Abstracts.

Edward Oravec, in his paper, made a strong plea for more observations of more variables of the RV Tauri-type. Of the 72 RV Tauri variables listed in the Kukarkin and Parenago *General Cataiogue of Variable Stars*, perhaps a dozen are suited to visual observations, but less than half of them are included in the current A.A.V.S.O. programme. More stars of this class will be added as rapidly as we can get charts and good sequences of comparison stars for them.

The selection of suitable comparison stars and the determination of good magnitudes for them remains the greatest stumbling-block in the addition of new variable stars to an observing programme. It is our great hope that more observatories with

photoelectric equipment can be interested in obtaining good magnitude sequences on the visual scale for variables brighter than the 11th magnitude at maximum.

The paper given by John Ruiz is an excellent example of what an amateur observer who is photoelectrically inclined can accomplish. Mr. Ruiz took part with 14 other observatories in a world-wide campaign organized by the Dutch astronomer, Dr. de Jager, to get a complete light curve of the rapidly changing variable DD Lacertae. This 5th magnitude star has a period of 4½ hours and an amplitude of only a few tenths of a magnitude.

Thirty-one new annual members were elected at the Spring 1958 meeting. They include the following: Ronald M. Bales, *Oregon*; Dale Brechlin, *Wisconsin*; Mrs. Sheila Philip Burnford, *Ontario, Canada*; Mary Churns, *New York*; Kenny Fuller, *Arizona*; Norman B. Godfrey, *Texas*; Robert B. Ingram, *Alaska*; Dan Judd, *New Mexico*; Howard Laskey, *Rhode Island*; M. Lattey, *British Columbia, Canada*; Hing-chai Liu, *Hong Kong, China*; Madison Jr. Astronomical Society, *Wisconsin*; M. H. Major, *Texas*; Alan McClure, *California*; Edward T. McCool, *Massachusetts*; Luiz Muniz-Barreto, *Rio de Janeiro, Brazil*; Philip J. Peters, *California*; Kenneth F. Powell, *Pennsylvania*; Bolton C. Price, *Mississippi*; Rittenhouse Astronomical Society, Observing and Computing Section, *Pennsylvania*; Jimmy Dail Rouse, *Texas*; Gerald L. Schubring, *Illinois*; Walter Semerau, *New York*; William M. Silveira, *California*; Harley Wright Smith, *California*; Henry E. M. Specht, *Connecticut*; William Swyers, *New York*; Henry W. von Rosenvinge, *New Hampshire*; Raymond N. Watts, Jr., *Michigan*; Ronne S. Waud, *Illinois*; Craycroft F. Wilson, *New York*.

Miss Harwood gave an outline of the life of Maria Mitchell and told of her discovery of a new comet on October 1, 1847. For this she gained world-wide recognition, and became the first American and the first woman anywhere to receive the Gold Medal given by the King of Denmark for the discovery of a comet too faint to be seen without a telescope. The Maria Mitchell Observatory was dedicated in 1908. It was built to house the 5-inch Alvan Clark refractor which had been given to Miss Mitchell in 1858 by the Women of America.

Members of the A.A.V.S.O. had two beautifully clear nights during the long week-end to try out the 5-inch Clark and the smaller telescopes set up on the upper deck of the observatory. Saturday night became an observing night, with Clinton Ford getting some of his Inner Sanctum variables with the Clark 5-inch, and aurora and meteor observations organized by the Observing Group of New York. Observing continued until dawn, when a fine sighting of Sputnik III was made. Miss Hoffleit kept the observers going through the night by supplying them with coffee and cookies at frequent intervals.

In spite of the long night of observing, the bird walk scheduled for early Sunday morning was well attended. It was a very successful walk under the guidance of Mrs. Clinton Andrews, and a number of "firsts" were obtained by the members.

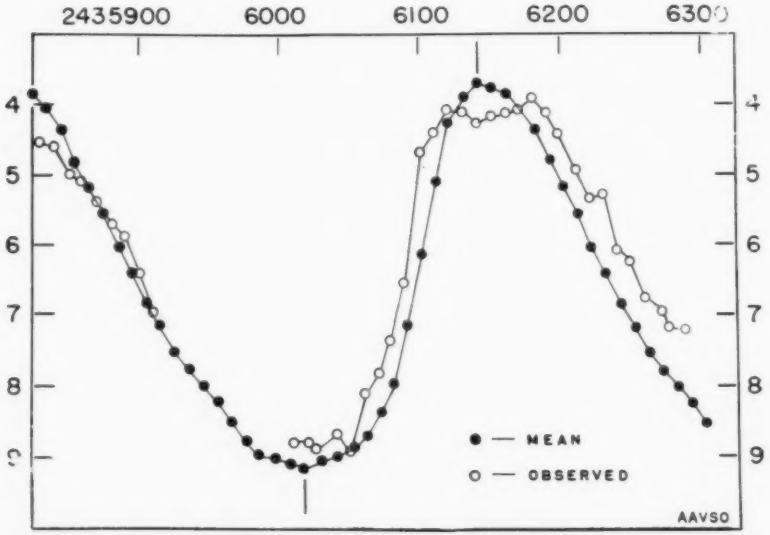
Several A.A.V.S.O. anniversaries have been celebrated during the last year. On September 24, 1957, Clinton Ford observed R. Scuti, exactly 30 years since he made his first variable star observation for the A.A.V.S.O., also of R. Scuti. On March 1, 1958 Leslie Peltier made an observation of R Leonis, repeating his first observation of exactly 40 years ago. Mr. Peltier also has the enviable record of not missing a report any month. Thus his report for March 1958 was his 480th consecutive report.

On May 20th, Cyrus Fernald made his 90,000th variable star observation. And Reginald de Kock writes that he hopes to pass his 100,000 mark during 1958. He started observing in 1933, but did not send his observations to the A.A.V.S.O. until some time in 1934.

An Unusual Maximum of Mira. Mira (021403 o Ceti) is one of the most interesting of the long-period variables, and a study of the variations and peculiarities of its light curve is always rewarding. The best way to see these peculiarities is to superpose a mean light curve on the observed curves. Probably the best mean curve is that computed by Leon Campbell from about 11,000 observations distributed over about 40 years (see *Studies of Long Period Variables*, Leon Campbell, A.A.V.S.O., Cambridge, Mass., 1955). The mean time of the rise from minimum to maximum is 118 days, and the mean period from maximum to maximum is 331 days.

Mira is situated near the ecliptic, and for nearly 3 months (from the middle of March to June) of each year, it is too near the sun to be observed. Observers are asked to follow it as long as possible as it nears the sun in the western sky and to pick it up again as soon as possible, when it reappears on the other side of the sun in the morning sky.

The minimum of 1957, predicted for July 10, probably occurred about 10 days early, nearer June 27. When the first observations were made in June, Mira was somewhat brighter than expected, and its minimum magnitude was about 8.8, four tenths of a magnitude brighter than the mean value. After minimum, Mira started a rapid rise, and appeared to be having an early maximum. One hundred and ten days after minimum, Mira was nearly 4th magnitude, and then started to decrease. Instead of continuing the decrease, it began to rise again, and 160 days after minimum it was a little brighter than the 4th magnitude. It then started a steady decrease, and when the last observations of the season were made, toward the end of March, it was a little fainter than the 7th magnitude.



021403 o Ceti, Broad maximum of 1957–1958.

The accompanying light curve shows the observed 10-day means plotted as open circles, and the Campbell mean curve (solid dots) superposed on it.

The observed curve at this epoch, the 398th since Fabricius discovered the variation of Mira in 1596, is about 40 days wider than the mean curve. Usually, when the observed curve is wider than the mean between the 5th and 7th magnitudes, the maximum is a bright one, but in this case the curve has the appearance of being cut off at the 4th magnitude. It will be interesting to see what the next maximum looks like.

Observations received during May and June 1958. A total of 10,468 observations was received, 3,621 from 57 observers in May, and 6,847 from 68 observers in June.

Observer	May		June		Observer	May		June	
	Var.	Ests.	Var.	Ests.		Var.	Ests.	Var.	Ests.
Adams, R. M.	69	147	80	182	Maran, S. P.	21	32	..	..
Allin, R.	37	195	32	153	Matte de Lira, E.	..	..	3	5
Anderson, C. E.	108	136	167	251	McPherson, C. A.	11	11	15	15
Anderson, E.	8	50	8	44	Miller, R. W.	..	..	18	18
Ball, A. R.	..	..	11	11	Miller, W. A.	4	4	..	..
Beidler, H. B.	..	..	14	17	Montague, A. C.	21	38	32	50
Berg, R.	5	5	..	..	Morgan, F. P.	19	37	6	9
Bicknell, R. H.	13	79	16	149	Mueller, J.	..	..	15	417
Braune, W.	..	..	22	36	Oravec, E. G.	169	373	158	249
Breckinridge, J.	5	5	6	11	Panke, D.	1	1	3	3
Buckstaff, R. N.	..	..	9	23	Parker, P. O.	75	87	56	56
Carlisle, J. H.	1	1	1	2	Pearcy, R. E.	3	3	4	4
Charles, D. F.	10	15	..	..	Pearlmutter, A. E.	..	..	32	75
Cragg, T. A.	135	136	216	221	Peltier, L. C.	13	29	17	67
Darsenius, G.	13	26	..	..	Peters, P.	3	3	14	14
Diedrich, DeL.	1	3	1	1	Price, F. J.	18	40	17	35
Diedrich, G.	6	15	11	26	Quester, W.	6	19	9	168
Engelkemeir, D.	8	17	8	12	Renner, C. J.	68	68	219	219
English, J. D.	3	4	4	5	Rizzo, P. V.	12	15	12	18
Erpenstein, O. M.	7	10	2	2	Robinson, J. C.	..	..	13	13
Fernald, C. F.	147	397	173	441	Robinson, L. J.	50	57	1	1
Fletcher, D. M.	9	13	7	7	Rosebrugh, D. W.	14	68	7	52
Ford, C. B.	194	204	75	76	Rosenfield, C. C.	32	113	18	40
Garland, G.	6	39	5	32	Rudolph, R.	25	100	170	2446
Gemberling, R. H.	3	5	..	..	Segers, C. L.	..	..	30	109
Godfrey, N. B.	..	..	4	4	Seldon, P.	..	..	25	61
Goodsell, J. G.	1	1	2	2	Sharpless, A. P.	14	14	..	..
Halbach, E. A.	..	..	26	30	Silveira, W. M.	4	5	5	9
Hall, G.	..	..	2	2	Sloan, M. A.	..	..	2	3
Halvorson, D. O.	9	32	..	..	Solomon, L.	21	31	9	20
Hartmann, F.	104	118	116	123	Taboada, D.	69	69	..	..
Hein, G. J.	..	..	3	5	Thurn, V. W.	..	..	9	12
Hiett, L.	..	..	7	17	Tsai, Chang-Hsien	26	28	18	24
Hutchings, N.	..	..	1	8	Valdez, M.	17	81	6	13
Kelly, F. J.	15	23	10	10	Venter, S. C.	..	..	49	132
deKock, R. P.	122	518	113	260	Weaverling, W.	..	..	5	5
Lacchini, G. B.	15	18	36	114	Wend, R. E.	..	..	19	29
Lowder, W. M.	8	8	28	40	Wilson, C. F.	2	2	38	133
Magruder, R. S.	13	28	6	6	Wyckoff, J.	25	33	..	..
Major, M. H.	6	12	..	..					

Future meetings of the A.A.V.S.O. The 1958 Annual Meeting of the Association will be held in Springfield, Massachusetts, during the week-end of October 10 to 12, at the kind invitation of Mr. Frank Korkosz, the new Director of the Springfield Museum of Natural History. Members who have attended meetings there in the past, at the invitation of the late Director, Mr. Leo Otis, know what an ideal location it is for a fall meeting. The nearby Berkshire hills and the Connecticut Valley are world famous for their brilliant fall coloring.

The meeting in the spring of 1959 will be in Chicago during the May 30th week-end. Our hosts will be the Chicago Astronomical Society. The Spring 1960 meeting will be in New York City, at the invitation of the American Museum-Hayden Planetarium and the Amateur Astronomers Association.

A.A.V.S.O. Nova Search Report (From George Diedrich, Chairman): Observations of Nova Search Areas were made by the following 17 observers for a total of 257 area-nights. Each name is followed by the number of observations made in April and then May, 1958: Robert M. Adams–0, 3; Richard Bates–0, 18; James Breckinridge–0, 4; Frank DeKinder–18, 10; DeLorne Diedrich–9, 5; George Diedrich–13, 24; Elspeth Fraser–15, 0; Geoffrey Gaherty, Jr.–14, 27; G. H. Hall–6, 0; Jack Morrison–9, 10; Beaufort Ragland–0, 7; David Sands–4, 0; Jane Shelby–4, 0; Robert Venor–0, 13; James Wesling–9, 7; I. K. Williamson–13, 5; D. Zorgo–10, 0.

This report is about 150% better than our mid-winter report and we trust that the coming dry and (we hope) clear season will bring in an even bigger number of observations. Of course, for this kind of observing, quantity is only of significance inasmuch as it makes it more certain that one of us will catch the next nova on the way up. Remember our slogan–"Keep Looking".

REVIEW OF PUBLICATIONS

White Dwarfs by E. Schatzman. Pages 180, 6 × 9 in. Amsterdam. Interscience Pub. Inc., New York, 1958. Price $5.50.

Since this book is very technical in content, it will not be of interest to amateur astronomers. This review is therefore concerned with its interest and usefulness to the professional astrophysicist.

After a brief account of the observation and discovery of white dwarf stars in Chapter 1, the author describes the meagre information available concerning their external physical characteristics in Chapter 2. Chapter 3 contains many calculations relating to the formation of spectral lines in white dwarf atmospheres, including the statistical Stark effect, hydrogen line profiles, and model atmospheres. Most of the matter in white dwarfs exists in the form of a degenerate electron gas, and many properties of this gas are discussed in Chapter 4, including pressure ionization, the pressure-density relation, modification of nuclei by electron capture, thermal conductivity, and opacity. Chapter 5, on the internal constitution of white dwarfs, includes a discussion of white dwarf models, the sorting of elements in intense gravitational fields, and problems of dynamic and vibrational stability. In Chapter 6 nuclear reactions at high densities are discussed. In Chapter 7 there is a brief account of the reasons why white dwarf stars cannot contain appreciable nuclear energy sources, and in Chapter 8 there are somewhat dated speculations about the origin and evolution of white dwarfs. The book also contains two brief addenda by J. L. Greenstein.

The book is very useful because it contains so much previously scattered information about white dwarfs. On the other hand its potential usefulness and certainly its interest have been very much diminished by the extreme brevity of treatment which most topics receive. Thus many of the symbols used in equations are not properly defined, and so many steps are usually omitted from the derivations of mathematical relationships, that the reader will usually find it necessary to consult the original sources in order to understand the development and limitations of the treatment.

This reviewer has been particularly interested in the accounts given of nuclear reactions at high densities. Schatzman's work on the variation

of the mean molecular weight per electron in some white dwarf configurations is very useful, and particularly the demonstration of dynamical instability when this variation becomes large enough. It is to be hoped that he will apply it to more realistic cases in which the nuclear charge changes by discreet amounts rather than continuously. Schatzman's calculations of the increased rates of nuclear reactions at high densities are not valid; at lower densities they have been superseded by better ones. His calculation of the rate of the 3 $He^4 \rightarrow C^{12}$ reaction is incorrect on two accounts: He calculates the probability of forming a compound Be^8 nucleus using a formula applicable to regions where there are high densities of nuclear levels, and uses it below the ground state of the Be^8 nucleus where there are no levels! In his numerical illustration of the rate of this reaction he uses an incorrect approximation to his own accelerated rate equations.

A. G. W. Cameron

Vol. 52, No. 5 OCTOBER 1958 Whole No. 434

Standard Time and Time Zones in Canada
C. C. Smith, revised by *M. M. Thomson* 193

An Instrument for Calculating Precession *D. H. Andrews* 224

METEOR NEWS *Peter M. Millman* 230

NOTES FROM OBSERVATORIES 233

VARIABLE STAR NOTES *Margaret W. Mayall* 234

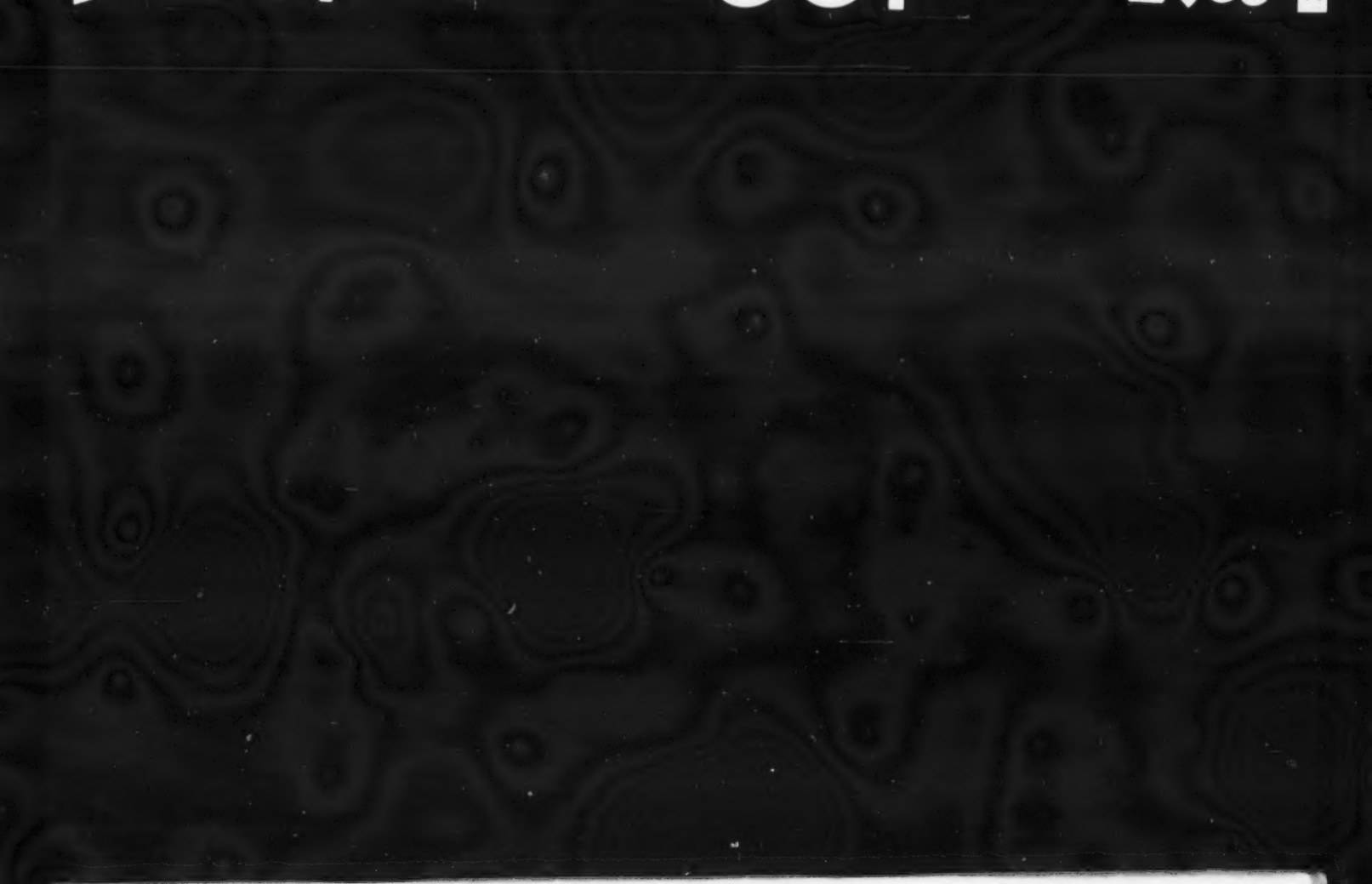
REVIEW OF PUBLICATIONS
White Dwarfs by E. Schatzman 239

EDITOR—Ruth J. Northcott ASSISTANT EDITOR—Leonard Searle

ASSOCIATE EDITORS—C. S. Beals, R. M. Petrie, A. Thomson

COMMUNICATIONS TO THE EDITORS SHOULD BE ADDRESSED TO

David Dunlap Observatory, Richmond Hill, Ontario

The Society publishes this JOURNAL bi-monthly (February, April, June, August, October and December) and the OBSERVER'S HANDBOOK annually. Single copies of either of these publications are 75 cents.

Membership, which includes the publications, is open to anyone interested in astronomy. Annual dues are $5.00; life membership is $75.00. Application for membership or publications should be made to THE ROYAL ASTRONOMICAL SOCIETY OF CANADA, 252 COLLEGE STREET, TORONTO 2B, ONTARIO.